MODERN PLASTICS

mp

APRIL 1942

CS

DONALD DESKEY, *Industrial Designer*

Built by the Langley Aircraft Corporation of New York, this 4-place twin-engined "Langley" plane uses Catabond #590 for all integral structural members and wherever motor heat might directly affect the bond.

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Catabond #590, a thermosetting resin glue of high molecular ratio, has been developed to fill a vital gap in the requirements of the rapidly growing aircraft industry. This resin cures permanently at 140°F. and produces uniform, dependable joints of typical phenolic resin performance.

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modern plastics


INTERNATIONAL NEWS

FIGHTING HATS

New spring hats for soldiers come in pairs this year. Under his protective helmet, the up-to-date fighting man will wear a plastic liner which he can don separately as a fatigue hat. Light, strong and durable, the plastic headgear will be fashionable in summer or winter, in Africa or Alaska. A complete story on the manufacture of the new helmet liner and its use by the Army Quartermaster Corps will appear in the May issue.

APRIL 1942

VOLUME 19 NUMBER 8

• GENERAL INTEREST

Marine bearings 33
Removing cylinder heads 35
Finding facts and figures 36
Molding tropical tools 38
→ Some views on plastics in wartime 39
Old records for new 46
Frozen dozen 49
Laminates and treated surfaces 50
Injection-molded Mycalex 54
All-America winners use plastics 58

• TECHNICAL SECTION

Acrylic resins for dentures 61
Plastics for water meter disks 68
Naftolen—its use in plastics and coatings 72
Plastics digest 76
Technical briefs 78
U.S. plastics patents 80

• NEWS AND FEATURES

Plastics in review 52
Stock molds 60
Publications 84
Machinery and equipment 86
Government and industry 88
In the plastics picture 90
Plaskon opens new laboratory 92

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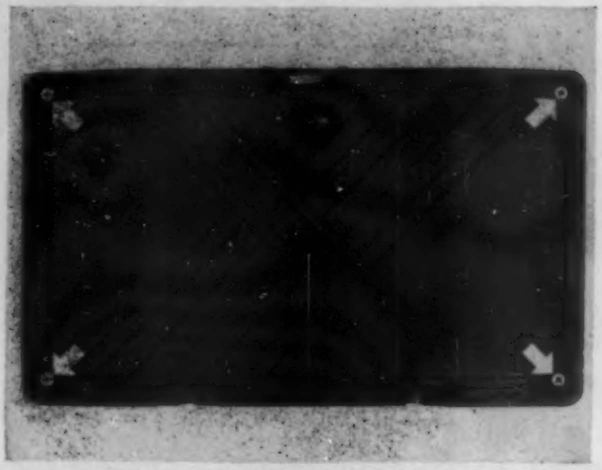

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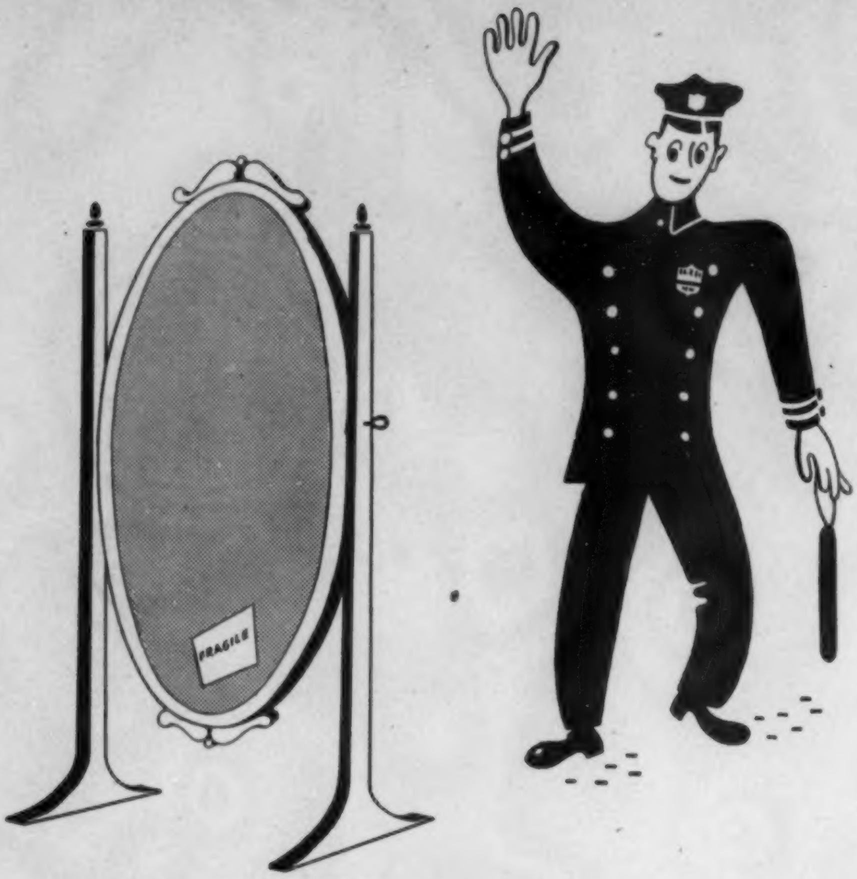

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- b. The basic raw materials must be allocated to other uses.

3. Therefor, every pound that a customer gets has to be taken away from some-one else, from some other use.

4. This is not the good old exciting game we played during Prohibition—a case right off the boat isn't anything to boast about to-day. In other words, bootlegging isn't only not funny—it's downright unpatriotic, if not worse.

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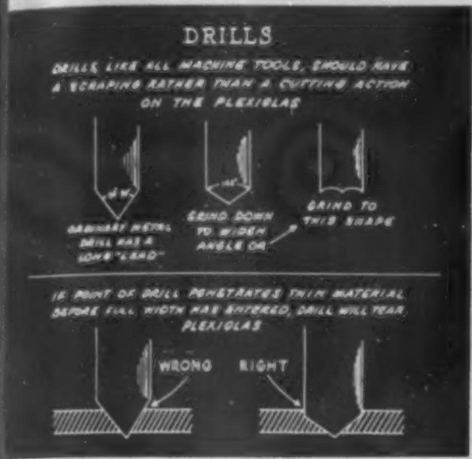
Drilling Plexiglas



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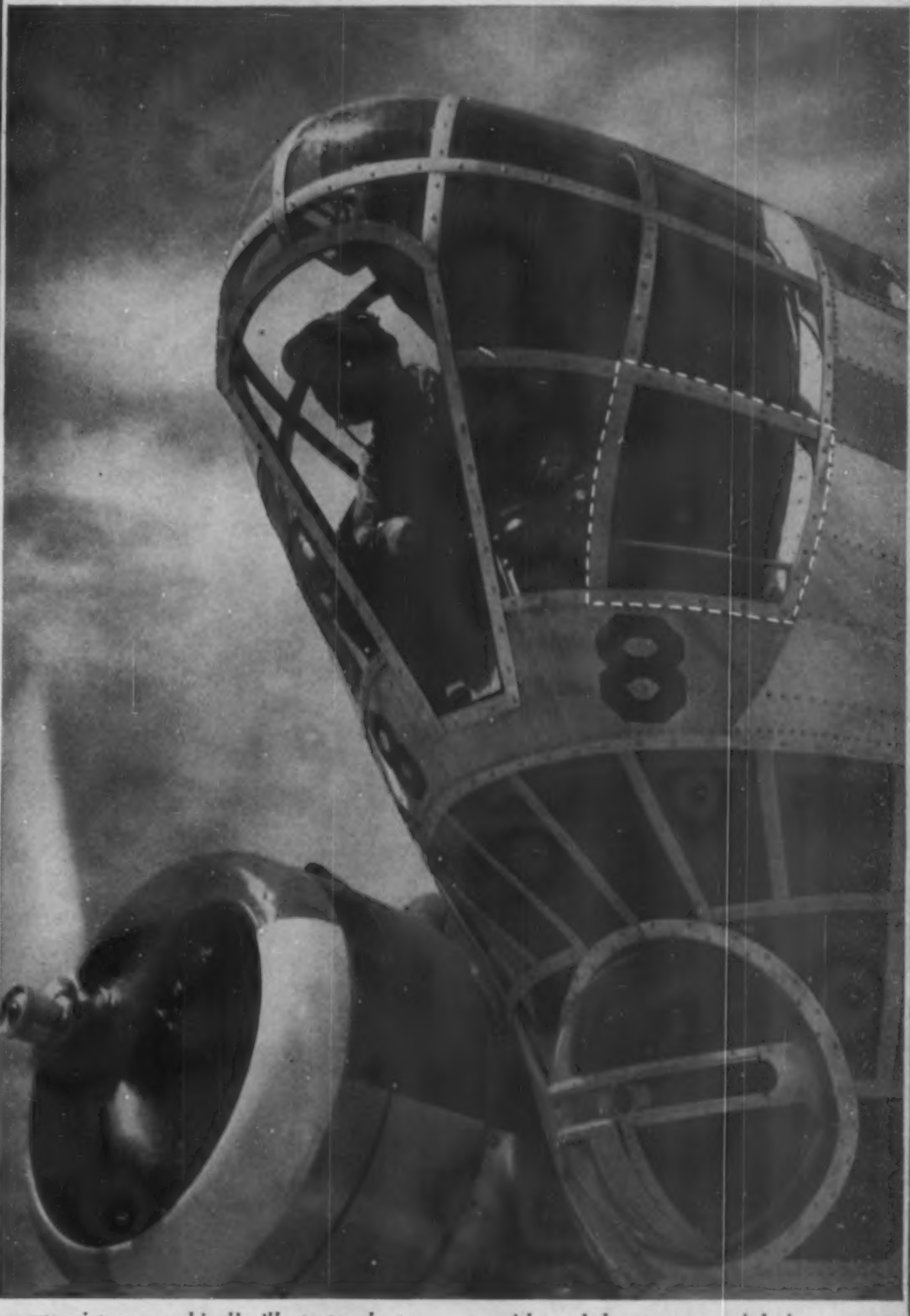

THIS picture graphically illustrates the tremendous importance of permanently transparent PLEXIGLAS *in modern aircraft. Through clear* PLEXIGLAS *sections that are able to withstand the most powerful air pressures, the bombardier of this Douglas bomber enjoys maximum vision in every direction.* PLEXIGLAS *is aviation's standard transparent plastic.*

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TO WIN THE WAR

Taylor Instruments are helping fill America's wartime rubber needs

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Here's some war work Taylor Instruments are doing. They help produce:

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Within the next few months, production of U. S. Signal Corps assault wire will be stepped up 300%. This latex-covered copper wire, so fine that one man can carry ¾ of a mile of it, is used to lay battlefront communication lines. It must be tough, sturdy, micrometer-exact in size, 100% reliable. It is cured by specially designed equipment completely controlled by Taylor Instruments.

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Just as C-D NON-metallics have helped make modern chemical fire-fighting equipment a "betterment," they can answer definitely your "What Material?" problem.

C-D NON-metallics possess many desirable properties not found in habitually used costly, heavy, corrosive materials . . . NOW so hard-to-get. When C-D NON-metallics are properly designed into your products they will make possible "betterments" that you will not want to give up.

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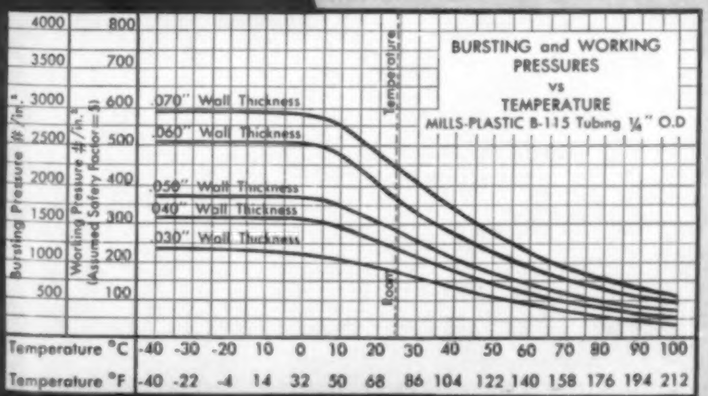

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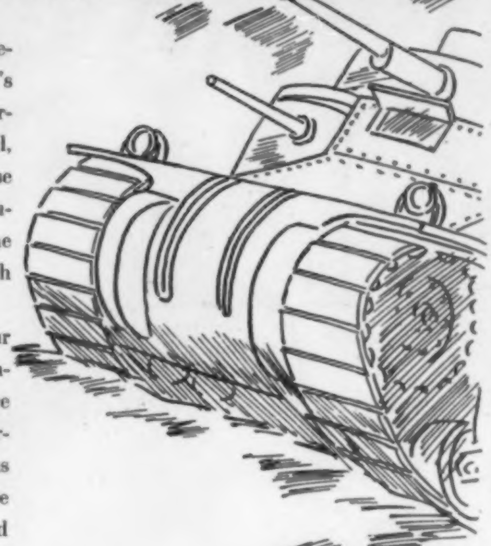
2081
To keep 'em rolling on the beam

PLASTICS HELP CARRY AMERICA'S ANSWER



Molded plastics are no longer substitute materials. They've become a vital part in America's fighting machine. Their exact di-electric properties, their imperviousness to moisture and oil, their flexibility of application . . . all of these things have contributed to making them a natural part of the planes, the tanks, the ships, the communications equipment, etc., with which America fights.

Here at Auburn we like to feel that in our sixty-six years of plastic molding we have contributed something to this present acceptance of a new war material. We *know* that our pioneering has opened the way to many new applications for molded plastics. Auburn molded parts are in use in tanks, airplanes, in army autos and trucks, electrical insulation parts for communication systems in the Signal Corps, Bureau of Ships, etc.

Right now, we are all out for America . . . and that's the way it's going to be . . . until the final blow has been struck at our foes.

If we can help America's victory program by helping you on your war orders . . . LET'S GET TOGETHER.

MOLDED PLASTICS DIVISION

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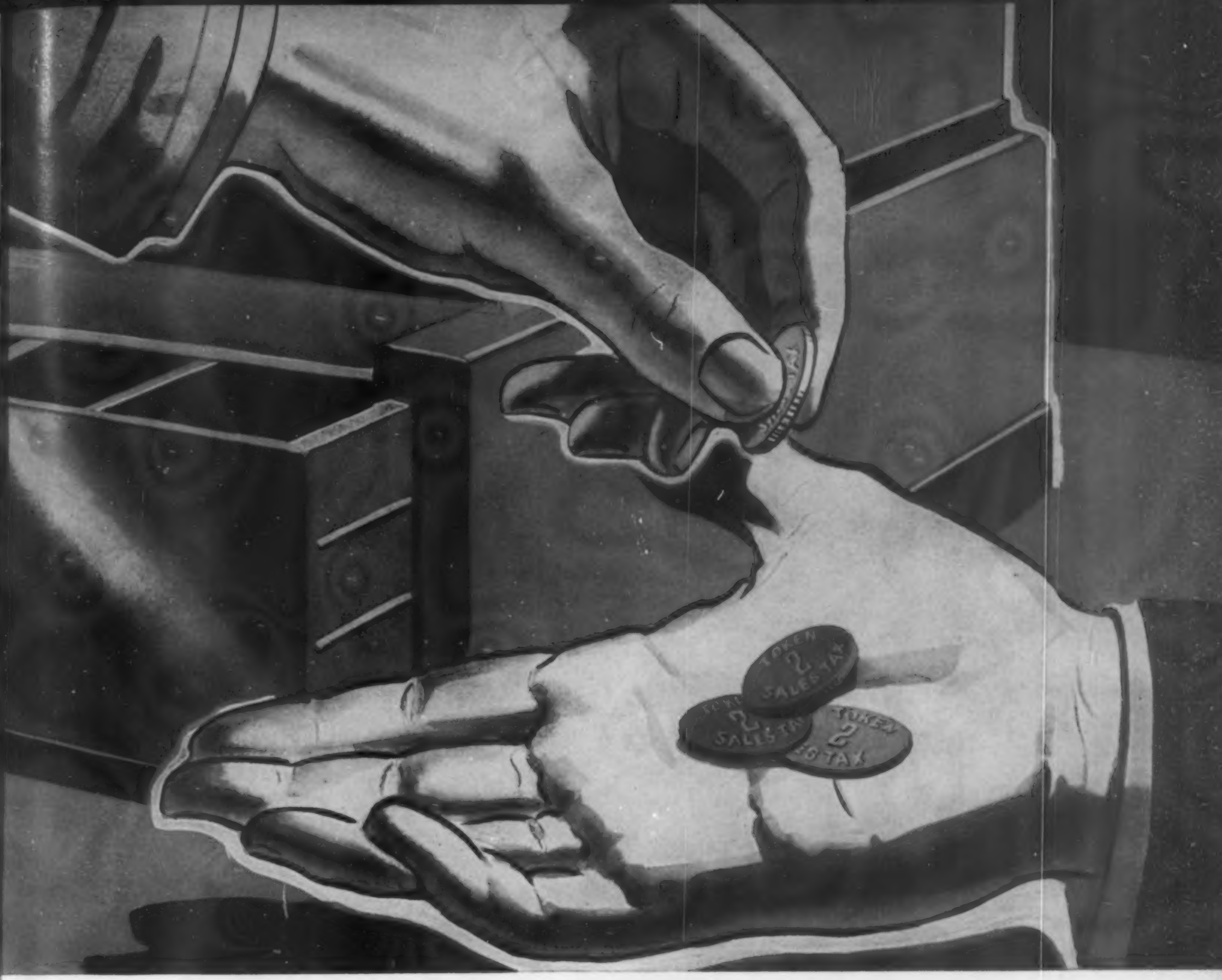
AUBURN, N. Y.



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Modern Plastics
APRIL 1942 VOLUME 19 NUMBER 8

Marine bearings

by H. C. IRVIN*

Laminated plastic bearings for stern tubes in ships show low rates of wear over long periods of service

GENERAL Douglas MacArthur, upon his arrival at Melbourne, Australia, issued a statement containing the following observation: "No general can make something from nothing. My success or failure will depend primarily upon the resources which our respective Governments place at my disposal." The men and materials that the General must have if he is to take the offensive against the Nipponese will need to be transported Down Under in fleets of merchant ships.

With Allied war hopes and plans thus so completely dependent on shipping, it is natural that the spotlight should be turned on many problems of ship design and construction. America's program alone calls for 18,000,000 tons of new shipping in 1942 and 1943. Every effort is being made to keep present bottoms in constant service—to improve efficiency at sea, to reduce lay-up time, to cut maintenance costs. These facts have served, among other things, to focus more-than-ordinary attention upon the problem of stern tube bearings—a problem as old as the steamship, and one which modern technology has brought closer than ever to full solution.

The use of laminated plastic for marine bearings, particularly in stern tubes, is not new. The advantages of these materials have been known for years to marine engineers and those responsible for ship maintenance. With American ship construction at low ebb, however, and shipping activity below normal over a period of years, the demand for plastic marine bearings was relatively small. Their progress, therefore, was relatively slow until the war emergency stirred new interest and activity.

Lignum vitae is, of course, the classic material for stern tube bearings. It held its place in this field for generations, because it was hard enough to serve its purpose, because it functioned satisfactorily with water lubrication—and because no better material had been developed on a commercial scale.

Laminated plastic stern tube bearings came into use, though not widely, six or seven years ago. Within the last three years, they have gained rapidly in popularity, largely as a result of revived shipping activity and increased interest in better materials and methods.

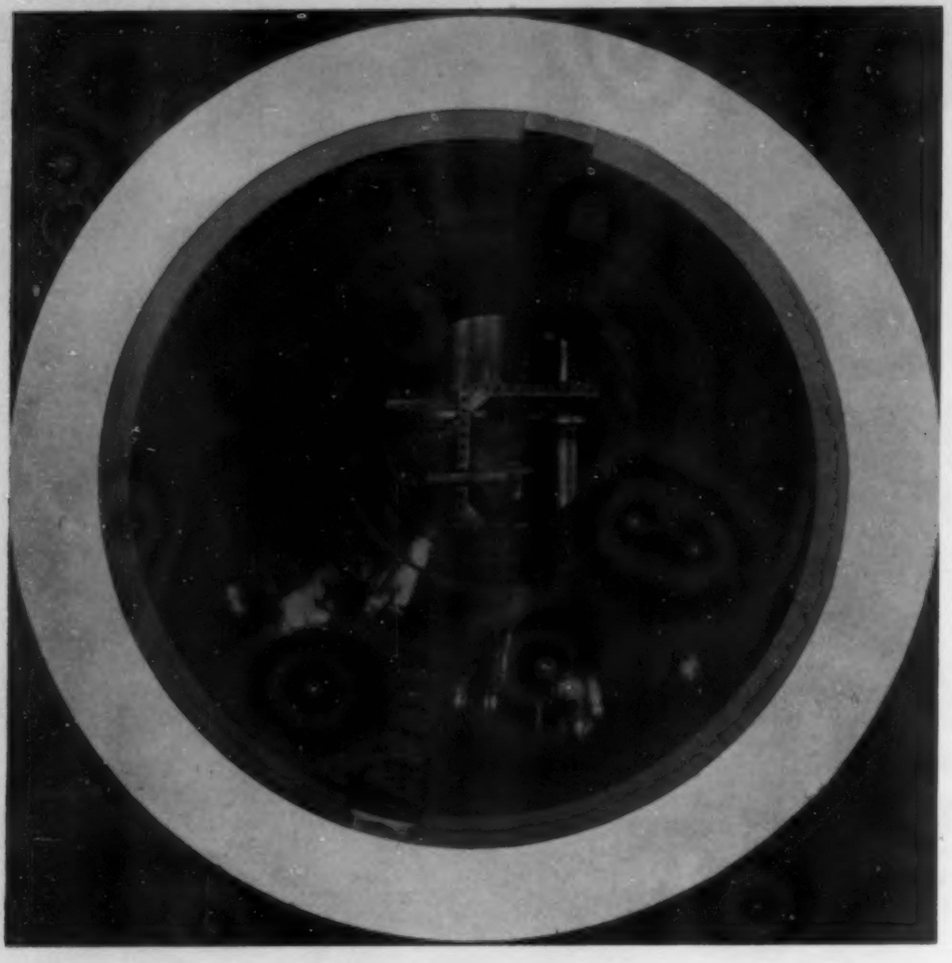
* Development Engineer, American Brakeblok Div., American Brake Shoe & Foundry Co.

Stern tube bearing design and installation present a number of problems peculiar to this particular application. The stern tube bearing is usually the largest bearing in the ship; in many respects it is the most vital one. It must last for years. It is subject to constant and severe stresses and strains. It is difficult to lubricate, except with water. It cannot be repaired or replaced except in drydock. The coming of bigger, faster ships has increased the load it carries, and has further complicated the problem.

The American Brakeblok Division of the American Brake Shoe & Foundry Company—manufacturer of brake lining and allied products, with a background of experience in the manu-

PHOTOS, COURTESY AMERICAN BRAKEBLOK

Finished segments of the "full arc" type of stern tube bearing undergoing inspection before they are installed. The laminated phenolic material has high structural strength, low water absorption, and is a good shock absorber. Chemically inert, it is not affected by pollution in river and harbor waters



"Full arc" stern tube bearing shown mounted in bronze bushing. The longitudinal keeper strips which separate the two segments serve as water channels for lubrication. Constant running will polish the shaft instead of scoring it, and wear will be slow and even

facture of laminated plastic bearings for steel rolling mills and general industry—has been one of the pioneers in the development of plastic bearings to meet severe marine requirements.

A-B-K Marine is a laminated plastic, a combination of phenol-formaldehyde resins and various fillers selected for the purpose they are to serve. In manufacture, the filler is impregnated with synthetic resin, then processed under heat and pressure. The resulting material is infusible and insoluble, and has other unique characteristics which make it particularly efficient as a bearing surface.

A-B-K laminated plastic has good resiliency, high compressive strength, good heat resistance and an extremely low coefficient of friction. Its water absorption is very low, and it is chemically inert. It weighs only half as much as aluminum (20 cu. in. per lb.). Its structural strength is extremely high. It can be sawed, drilled, punched, turned or cut by machine tools. It is unaffected by water, brine, oil, ordinary solvents, most acids and weak alkalis.

It can be seen from this brief description that laminated phenolic is not merely a substitute for other natural or manufactured materials, for no other material has anything like the same combination of characteristics.

Design and construction of stern tube bearings are governed by three main considerations: the length of service they give, the kind of service they give, and cost of maintenance and replacement. The success of laminated plastic is due to its ability to meet all requirements under these three headings.

This tough, resilient material shows a remarkably low rate of wear under the most severe operating conditions. In stern tube bearings, it has many times the life of lignum vitae. Because of its low friction and high shock absorption qualities, laminated plastic greatly reduces power losses, and substantially improves over-all performance. It maintains better shaft alignment, and constant running serves only to polish the shaft instead of scoring it. Compared with lignum vitae, laminated plastic has still other advantages. It is of uniform quality all the way through. It wears slowly, evenly, smoothly, has no grain with alternate hard and soft streaks, is not subject to cracks or heart rot. Being chemically inert, laminated plastic is not affected by long and constant exposure to oil, industrial wastes and other forms of pollution commonly found in river and harbor waters.

Many engineers require that a spare stern tube bearing be kept on board for possible replacement needs in a foreign port, and here again laminated plastic shows its superiority. It does not dry out or crack in dry storage, can be kept on hand indefinitely. And for the same reason, installed bearings need no special attention while the ship is in drydock.

From the ship owner's viewpoint, these many advantages actually add up into one major advantage: longer, better service per bearing, lower drydock charges for maintenance.

In designing plastic bearings for stern tubes, engineers have two important markets to consider: new shipping and replacements. And because the bearing in some instances must be adaptable to existing stern tube design, American Brakeblok manufactures laminated plastic bearings of three distinct types.

Our engineers recommend the "full arc" type wherever it can be installed. In this form (*Please turn to page 120*)

Removing cylinder heads

ON January 1, 1942, the sale of automobiles was restricted and motor manufacturers began converting to wartime production. On March 19, 1942, gasoline stations in the eastern seaboard and Pacific Northwest States were limited in deliveries and sales of gasoline. Public vehicles and private cars alike will now require extra care to "keep fit."

To get first-class performance from cars, prevent waste of gasoline and oil, hardworking portions of the car, such as the ignition and carburetion systems, the motor valves and pistons, need special care and attention. Distributor points, spark plugs and cylinder heads are trouble centers all too familiar. To check defects of this type, molded plastics have come to the aid of the automotive mechanic to help speed his "carbon and valve" job. A small transparent cup, used in combination with a penetrating oxide solvent, has been developed to solve the problem of locating and loosening frozen studs in cylinder heads, a preliminary step required before the mechanic can attack the valves. Called the Rose-Cup, this device was designed to eliminate breaking of cylinder heads which had become frozen with heat-hardened rust and oxide formations, lodged deep in their recesses. Usually removing these heads was a difficult job requiring from 4 to 6 hours, and the frozen parts had to be pried loose, often with resulting damage and expense.

With this device, a solution is poured into the plastic cup. This dissolves the corrosion around the frozen stud, permitting its ready removal without destroying the head.

Cups are injection molded of transparent cellulose acetate, four on a sprue (Fig. 2). Threads are molded-in and there is little finishing required except to remove the gate and runners. The clear material permits a view of operations, indicating how fast the solution is disappearing. Cups are unaffected by the solution, are durable, easily cleaned and will stand rough treatment. They are made in two thread sizes to fit standard $^{7}/_{16}$-in. studs and $^{3}/_{8}$-in. studs.

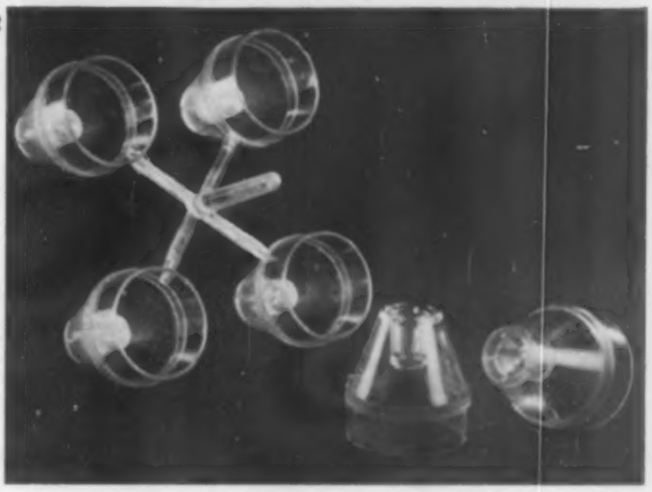
Use of the cups is simple. After the surface around cylinder head studs is cleaned, cups are carefully attached so that threads will not be stripped. A rubber seal holds them tightly in place. A small quantity of a special chemical compound which loosens the rust scale and disintegrates the formation which binds the head to the studs is poured into the cup. This trickles down through the tiny holes in the base of the cup, thus concentrating action around the studs until they are free. After about 30 minutes, excess solvent is removed from the cups with a bulb syringe (Fig. 1), cups are removed and then the cylinder head loosened.

By the use of these cups, frozen studs can be located very quickly. If the operator sees that the liquid begins to flow immediately or shortly after it is poured into the cups, he realizes that the studs beneath these are free. Thus he can concentrate on those which are evidently frozen. In addition, the cups permit a more efficient and economical use of the solvent than could be obtained by squirting around the studs, and leave the operator free for other jobs while the compound is at work.

Credits—Material: Plastacele. Molded by Caldwell Products, Inc., for Anti-Rust Corporation

1

2



***1**—Squirting a solvent around frozen studs in a cylinder head to dissolve corrosion and rust wastes time and material. Small transparent cups of durable cellulose acetate can be attached to the studs, the solution poured into them watched as it bores through. If the solvent disappears quickly, the stud is free. **2**—Cups come from the injection molding machine four on a sprue with molded-in threads, and require little finishing. They are unaffected by the solvent*

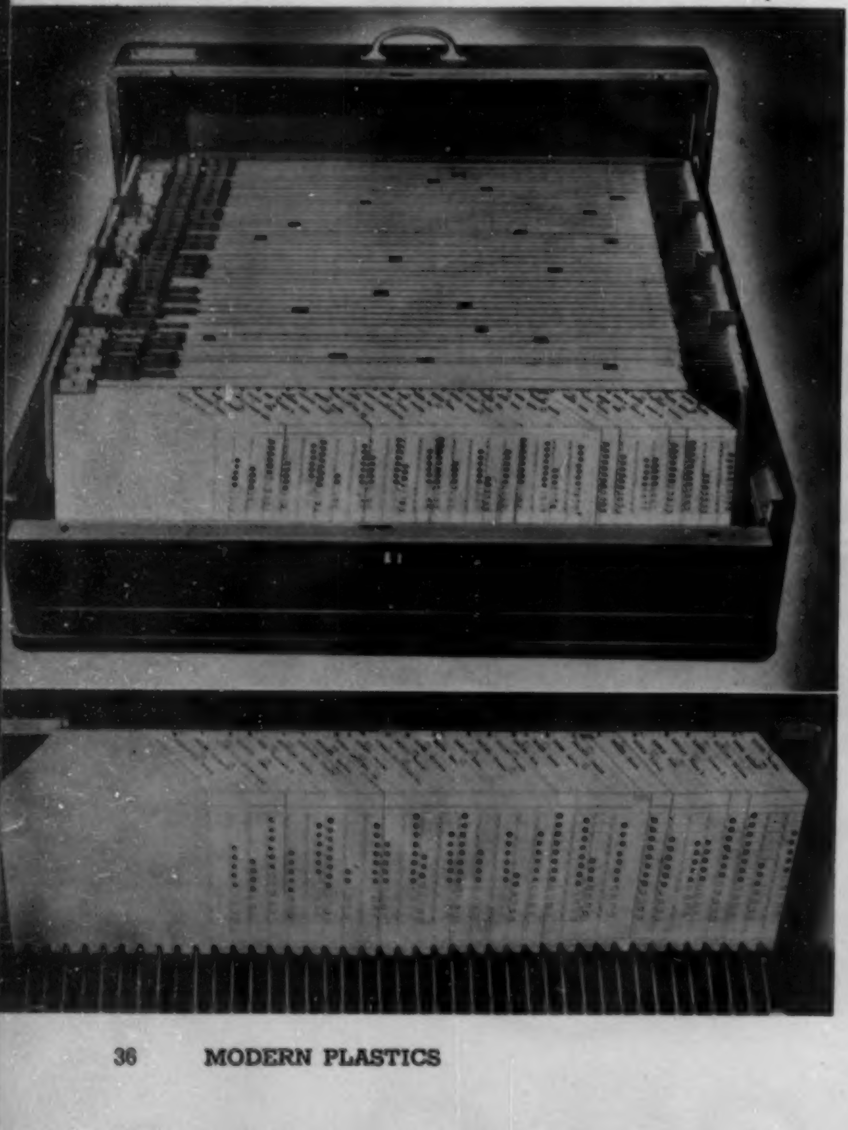
Finding facts and figures

ON Tuesday, March 17, 1942, the nation's third draft lottery was held to start the massive machinery of classifying 9,000,000 men for military service. Add to this number the 17,000,000 men affected by the first draft of October 1940, and the 750,000 subject to conscription after the second lottery, on July 17, 1941, and it is evident that there's a lot of bookkeeping involved in keeping track of our new army—and, in fact, of all war and production activity. Efficiency in record keeping in all the Services, in every Government department, throughout the war and civilian industries, in schools and hospitals, is of tremendous importance today. We cannot afford to be without vital data, and this information must be accurate, clear, concise and instantly accessible.

The job of keeping track of selectees is probably the superlative in filing problems, but for this extreme, or for the regular activities of business organizations, public and private institutions there must be adequate, speedy methods of posting and finding data. The Visible Index Corp. has developed compact equipment and a system of visible vertical record keeping which permits location of required records in split-second time, allows both machine and hand posting, is space-saving and easy to maintain. With the incorporation of various types of plastics—extruded strips in various colors for end rails, top and bottom strips, fabricated index tabs—into the equipment, the company was able to improve methods of segregating records, and consequently make them easier to find. They reduced their manufacturing time, improved the appearance of the equipment, minimized noise of handling and reduced weight and maintenance costs.

The distinguishing feature of this record system is its method of filing cards vertically in echelon, a step-like arrangement with each row of cards parallel with the others but not in the same alignment (see Fig. 1, top). Each bank of cards is separated from the next by a dividing panel which can tilt either forward or backward at a 20 deg. angle. This permits ready visibility and manual access to information on the three visible margins of the "VISIrecord" card or record forms thus exposed, from either the front or rear of the posting tray or from either side of the drawer equipment. The card forms are die cut at the bottom with notches equally spaced, depending on the desired visibility of the margins of the card. These notches straddle correspondingly placed spacer rods, thereby effecting a predetermined margin of visibility on the cards which ranges from .5 in. and .6 in, to any desired multiple thereof. (*Please turn to page 98*)

1

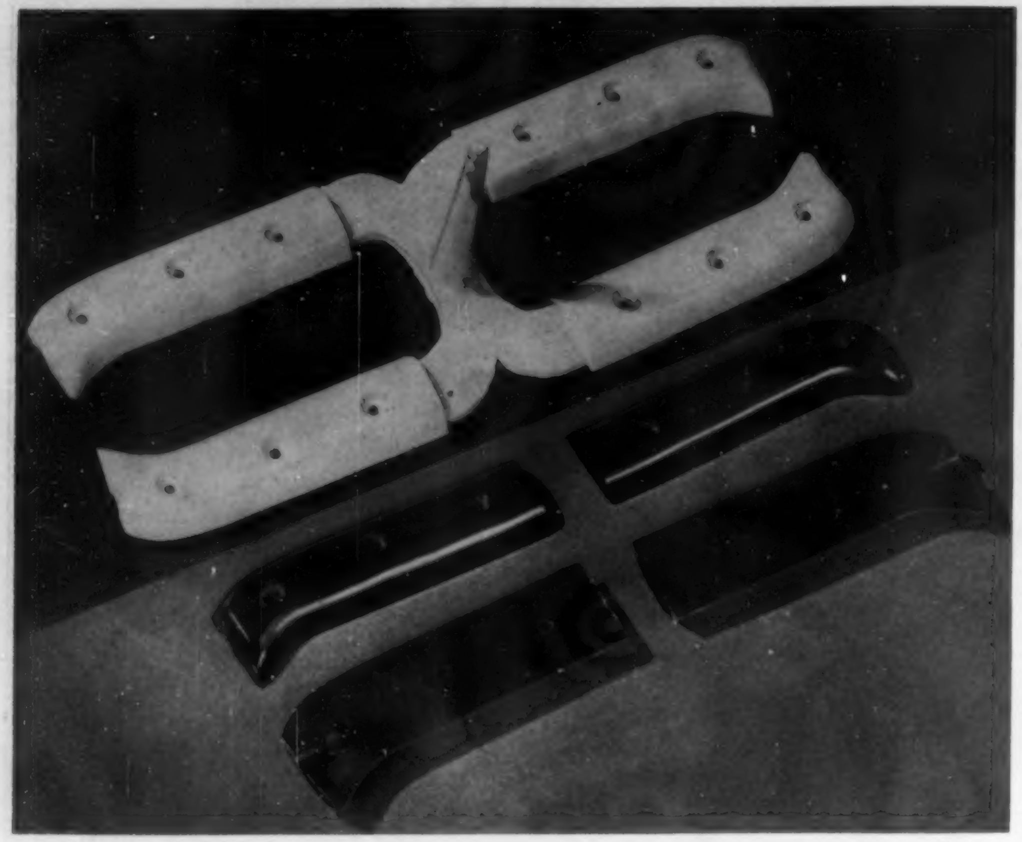


2

3

COLOR PLATES AND PHOTOS, COURTESY TENNESSEE EASTMAN CORP.

Colorful extruded cellulose acetate butyrate end rails, transparent tabs and panels improve the appearance and facilitate rapid posting and finding of records in this modern filing equipment. **1** *(top)—Compact posting tray holding 5000 cards. Dark rectangles are controls indicating missing cards. Lower photo shows bank of Visi-record cards resting on corduroy, over equally spaced separator bars.* **2**—*Cut end rails of various lengths, and ends of the dividers showing attachment.* **3**—*In the three portable trays mounted on the table above, the operator can see at a glance the territory desired—West, Midwest, East—each of which is indicated by a different color divider strip*



Molding tropical tools

Ingenious mold construction facilitates efficient production of heavy machete handle sections

HALF knife, half cleaver, the vicious looking tropical-born machete, sturdy work tool of the rubber gatherer, sugar cane harvester, jungle traveler and the cutlass of the native warrior, holds its own among the implements of the modern workman or soldier. Naturally, a handmade or carved machete handle is too expensive to produce in large quantities. Modern manufacturers have made these handles from many materials, including a phenolic-impregnated fiber board. However, it was found to be difficult to obtain an economical wooden handle with dimensions sufficiently accurate to meet standards specified for high quality production.

When the Lilley-Ames Corp. turned from the manufacture of thermoplastic Navy dress sword handles* to producing handles for the serviceable machete, its previous experience called attention to plastics. According to that company, the moisture-resistance of the plastics substituted for wood and sharkskin sword handles indicated that thermoplastics might also be used for these heavy-duty machete handles. Tough, moldable cellulose acetate was selected to do the job and it was decided to build dies to form the right- and left-hand pieces of the handle by the injection molding process. Handles are molded two on a sprue, as shown in the above photograph. Halves are then riveted on.

Since there are no valid rules for determination of material shrinkages, experimental runs for this purpose were made on a single cavity die. This preliminary work enabled the pin holes to be very closely located in relation to each other and to the outside edges of the handle, with a minimum of "cut and fit" in the final die.

All pieces had to be readily interchangeable and to fit the standard blades without alterations, which led to the discovery of the need for the wide gates discussed below to control shrinkage and dimensions.

Construction of the mold

The draft on the lower or blade end of the handle is removed by grinding after molding. This draft is necessary for easy removal of the piece from the die; and this end of the handle was the obvious place to gate, since grinding was already necessary. It also ensures accuracy between the first pin hole and the end of the handle, and removes any porosity common in the vicinity of the gates. Porosity is sometimes found in gated areas where heavy (*Please turn to page 96*)

* A story on this molded sword handle will appear in an early issue.

Some views on plastics in wartime

A brief report on the plastics industry conference held in Washington, D. C., March 2, under the auspices of the Society of the Plastics Industry, was given in the March issue. In the belief that the timely papers presented at this conference by members of the Government Services will be of unusual interest to our readers, we are reprinting three of them in full. The extemporaneous talks given by Capt. E. L. Hobson of the Quartermaster Corps and by Col. M. B. Chittick of the Chemical Warfare Service are, unfortunately, not available for publication. It is to be understood that the views expressed in these articles are those of the writers themselves, and are not to be construed as necessarily those of the Services they represent.—ED.

Ordnance developments

by LIEUT. E. T. McBRIDE*

SINCE the President's declaration of a limited National Emergency 22 months ago, the Ordnance Department, through its research staff and manufacturing facilities, has been investigating the possibility of substituting plastic materials for critical metals in some of its matériel. The substitution has been slow and very few components have reached the stage of standardization, but the investigation has been very thorough.

A problem of this magnitude is best solved by treating it as a genuine military situation. Like all military situations which are active, it must be estimated daily. The objectives must be known, plans for attaining them formulated and positive action taken. It is by this method that the Ordnance Department is developing its program. The individual components undergoing substitution are regularly reviewed and progress noted, the availability of raw materials closely followed and the operating facilities carefully instructed as to what materials are considered satisfactory for the particular component.

When a metal, for example, is declared "critical" by the War Production Board, immediate action is taken to effect a substitute for that metal. This substitute must be satisfactory to the using service from the standpoint of its ability to function efficiently, wherever the theater of operations may be. It must be readily available in quantity at a non-prohibitive price and must be capable of withstanding long periods of storage in various climates under the most adverse conditions. It must provide permanence of form and resistance to wear, abrasion and impact whether in the sub-zero weather of the Arctic outposts or the torrid humidity of the tropics. At this time, only the thermosetting compounds show definite promise. They alone have satisfactorily filled every Ordnance requirement, and it is for these reasons that thermoplastics have not been approved for matériel manufactured for the combat forces.

Small arms

With this background of the general situation, we are ready to review the particular problems confronting the operating divisions. The Small Arms Division, for example, has been particularly active in plastics substitution. For almost a year this organization considered plastics for the M-1 rifle stock and hand guard, for the Browning automatic rifle stock and for machine gun belt link. It has been shown that plastics have not yet reached the state where they can take the place of black walnut. The weight of the stocks, their tendency to absorb and hold heat and their relatively poor flexibility made their substitution impractical. The belt link, thought of as an ideal thermoplastic application, stretched under the weight of the ammunition, warped and fouled before reaching the guns, showing that this was definitely a misapplication. The Small Arms Division has succeeded, however, in providing some plastics substitutes for critical materials. Reproduction of the brass lead tip on either end of the .30 caliber machine gun belt in a phenol-formaldehyde impregnated paper composition shows promise. This group has found that molded grips and handles, being exact replicas of the dies in which they were molded, assure uniform and accurate assembly. They have found that grips and handles for pistols, machine guns and bayonets which are superior to the walnut furniture may be obtained at no extra cost. They have therefore termed an "alternate standard material," any medium impact phenolic having an impact strength of .23 ft. lb. energy to break (on the notched Izod impact specimen) as determined by the A.S.T.M. Izod Impact Test, and which can meet the requirements of the Springfield Armory tentative specification for molded phenolics shapes.

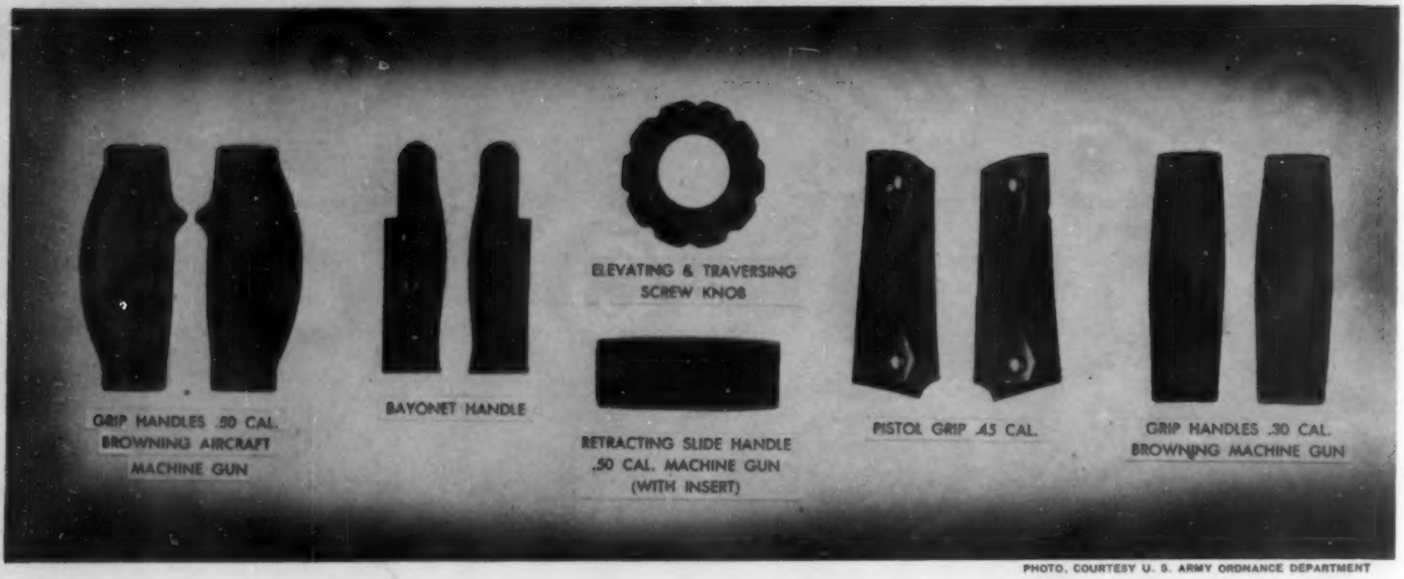
The thermoplastic exception in this program is the bayonet scabbard on which Rock Island Arsenal has prepared a tentative specification. This item is a cotton millduck impregnated cellulose acetate butyrate composition. Although a large number of these scabbards have been procured, a number of thermosetting compounds are being investigated with the hope of obtaining a scabbard more capable of withstanding storage and weathering.

Ammunition

The Ammunition Division has also been actively investigating the utilization of plastics. The well-known M-52 fuse is an excellent example of cooperation between the Army and industry. Although not yet completely tested, it seems logical to assume that a medium impact phenolic molded by the transfer process will be satisfactory as an alternate standard material for manufacture and issue. Like the Small Arms Division, the Ammunition Division requires materials which will function properly regardless of the climate and in spite of forces set up in a gun during firing. This fuse is designed for both the 60 mm. and 81 mm. trench mortar.

The windshield for 37 mm. armor piercing ammunition will require a high impact phenolic which is not only capable of withstanding "setback" stress (forces generated on firing) but also the rotational forces of flight without breaking or separating from the projectile before reaching the target. This component shows some promise and is still undergoing investigation. (*Please turn to next page*)

* Industrial Service Research and Engineering, Office of The Chief of Ordnance, U. S. Army.



PHOTO, COURTESY U. S. ARMY ORDNANCE DEPARTMENT

A group of grips and handles for small arms molded of thermosetting phenolic material. Costing no more than walnut, the plastic is an "alternate standard material" for these applications

Although the Ordnance Department has suspended experimental development of the 75 mm. windshield because of constant "setback" failures encountered in firing, private industry is still conducting developmental work. It must be remembered that the plastic that overcomes the "setback" will have to withstand a force of 17,000 pounds per pound. All windshields of this caliber fired to date have exhibited longitudinal cracks which start at the threaded section. This shows that the differences in thermal expansion of metal and plastic are too great and/or the plastic materials used do not have sufficient elasticity to bend with the projectile.

Classified as "plastic alternate standard" is the dummy fuse which is used for the 37 mm. gun for target practice. Although powdered iron is also acceptable and has provided a more inexpensive procurement source, the industry will probably be pleased to learn that the Ordnance Department is interested solely in obtaining a fuse capable of meeting with weight, weathering and temperature requirements. The fuse must, of course, be concentric and perform satisfactorily in the gun, in flight and at the target—which may be 4000 yds. from the gun.

It can be readily seen then, that the "volume applications"—or the use of plastics in ammunition components—is definitely limited because of the inadequacy of modern plastics to meet ammunition requirements. In many cases plastic components have cracked badly in loading and feed mechanisms, causing failure. In other cases, the temperatures of explosion exceed by far the upper limit of plastic temperature resistance. What is needed, then, is a plastic material which is capable of withstanding high temperatures for short periods of time and high "setback" pressures simultaneously. There is no doubt that a properly designed 75 mm. windshield, for example, carefully molded from a specially designed high impact thermosetting compound, can be developed. A good combination of these three factors is what the Army wants.

Aviation

Aviation Ordnance is rapidly growing and, with the scarcity of aluminum, requires materials for booster cups, bomb detonators and aircraft signals. The bomb fuses, once thought of as a practical application, will probably never become plastic components because of the "drop safe" requirement, which no plastic has been able to meet. To "drop safe" is to release a fused bomb in an unarmed condition from an airplane at, for example, an altitude of 8000 ft. The bomb, so dropped, is expected to land without detonating. This requirement is necessary in order to enable Allied aviators to release bomb loads over friendly territory in the event that a forced landing becomes necessary.

The fabric-filled phenolic fuse booster cup has also failed. This component, when dropped 50 ft. after 48 hours at −40 deg. F., cracks and shatters.

The drawings for chemical bomb burster tubes are being revised to permit the use of an impregnated paper. They must be capable of being stored for long periods of time and must not enter into chemical reaction with the burster loading, tetryl.

The Ordnance Department, whose responsibility it is to provide the Air Corps with aircraft signals, has developed a base for these signals. Bases for such components may be molded of high impact phenolics.

Artillery, tanks and combat vehicles

The Artillery Division is developing a number of fire control components from plastic materials. Binocular eye and end pieces for field glasses and telescopes are excellent applications for medium impact phenolics. Protractors and the two-range deflection fans are items where transparent plastics capable of retaining their original shape without warping may be used to advantage. Handwheels and knobs molded with inserts are needed for gun directors, aiming circles and for battery commanders' telescopes. These are also suitable applications for medium impact phenolics.

The use of plastic parts on artillery weapons is not common practice. There are a few places where plastics may be used. It has been suggested that elevating and traversing mechanisms be equipped with plastic handwheels. Handwheels of high impact phenolic containing steel inserts have been submitted for examination and proving ground tests. If these handwheels are satisfactory with respect to durability, temperature resistance and physical properties, they will be considered for adoption. (*Please turn to next page*)

Fans and master clutch flywheels of laminated wood or canvas are being investigated for use on engines by the Tank and Combat Vehicle Division. Both components have been standard aluminum parts and now, due to the shortage of this metal, a substitute must be found. A fabric base laminated phenolic is believed to be a substitute worthy of consideration, providing the water absorption property of this material can be appreciably reduced. It may well be that a macerated canvas will satisfy these tank components.

Experimental work is being conducted to investigate the possibility of using high impact phenolics for elevating and traversing mechanisms on tank guns. These handwheels will have exactly the same requirement as the artillery component.

Consideration is being given to the use of synthetic elastomers such as neoprene in place of rubber grommets on oil and electric lines. There is a definite military requirement for a "windshield blister" on tanks. This "blister," which is similar to the transparent domes used on bombardment aircraft, is to fit over the tank commander's turret, and is to be used when on reconnaissance missions, with the hatch open. The purpose of this component is to protect the tank commander from dust, dirt and gas fumes which may be present in enough concentration to impair his vision.

The Ordnance Department is now in the midst of enlarging the gage industry in order to assure an adequate supply of plain, cylindrical and thread plug gages so essential to the armament program. In the American gage design standards, three types of handles are employed, namely, the taper lock design handle, the reversible design handle and the ball handle. The handle, incidentally, is that portion of a gage which is employed as supporting means for the gaging member or members. Until recently, the handles were made of aluminum. Thermoplastic compounds capable of meeting Ordnance Department requirements have been accepted as alternate standard materials. Cellulose acetate butyrate, cellulose acetate and ethyl cellulose compounds, properly formulated and compounded, will, no doubt, produce highly satisfactory handles.

In closing, allow me to thank the plastics industry, in the name of the Chief of Ordnance, for the splendid spirit of cooperation which has been shown throughout the substitution program.

Navy applications

by JESSE B. LUNSFORD*

THIS is not a speech, not even a technical discussion on plastics as such. It is only a bit of homely "talkey-talk" such as might be given to anyone who visited the Bureau during office hours and inquired, "What is the Navy doing in plastics?" or "How do we get our material approved so that we can help out in the Defense Program?"

So many people these days want to help out, and yet so many of them do not seem to know exactly how they can fit in. We have to tell very much the same story to so many people who do not know how Navy standards are arrived at, that it might be helpful if we could tell a good story once and for all, and not have to keep repeating it day by day.

What I shall have to say here does not apply to plastics any more than to anything else the Navy does. But since plastics is the business of this meeting, and since most of the plastics people are relatively unfamiliar with naval practices, it may be that some explanations here and there might serve a greater good than in the older fields of materials where everyone knows his way around better.

Plastics are just another material to us. If you want the glamorous side of plastics, look at the colored pictures in the magazines and Sunday newspapers, in the shop windows, and on milady's boudoir table. To us plastics has no relation to Superman, or to Buck Rogers that the boys read about in the comic strips. To us a plastic may be just another metal, or another insulator, to be looked upon not for what it is made of, but for what good purpose it will serve.

For a great many of our applications, the plastics must be a "toughie" for impact, in order to meet those high speed blows that they must take in service and still, somehow, hang together. They must suffer Arctic cold and worse than tropic heat. They do not have to swim, but they must not be afraid to go near the water. Rather simple, isn't it?

There are so many very different applications of plastics in the naval service that there isn't any one plastic or any one general class of plastic which will serve all purposes. It takes all of them to do the job, and even that is not enough, because there are even some jobs open for plastics for which there are no plastics as yet available. There are not even enough of the plastics we do have jobs for to go around. So it is rather useless to attempt here, in a short time, to go into any long and technical dissertation on what plastics can be used for or what are the trends. We do in fact use them for nearly everything, and the trend is in many directions. If we should start to break the subject down into specific details, we would shortly get mixed up in a lot of details, each one of which is a whole subject in itself.

One of the best things which can be said of plastics, however—and this is true of most plastics—the best thing about them is that somehow, if you go about it right, you can change them so that they will be good for your purpose; or you can combine them with something else so that you can almost always be sure of meeting your needs.

That seems almost like a left-handed compliment, grudgingly given, but it is not. It is a very important consideration because in so many other things one has to take what he can get and like it. When one does not like a plastic, one can change it, or get it changed, and that is really something these days.

What the Navy has done

One of the surprising things to me is that nearly everyone who lacks familiarity with what the armed forces are doing about the newer materials seems, somehow, to get the impression that nothing is being done. This is probably because when anyone on the outside gets a bright idea about how to win the war, he immediately jumps to the conclusion that he and he alone in all this world got that idea. It never occurs to him that some other people, as a regular full-time job, might already be acting upon what he, as one very recent and part-time thinker on defense problems, judges to be a good idea.

So nearly everyone tries to tell us that we should make use of plastics. Now if it were true that the Navy had really to be goaded into the use of plastics, that would have been bad, bad for the Navy. But it might have saved a lot of worry on the part of other people who manufacture goods for civilian uses. If the Navy had really been asleep in the matter

* Principal Engineer (Electrical), Research Branch, Design Division, Standards and Tests Section, Bureau of Ships, U. S. Navy.

of plastics, all those mandatory priorities on the raw materials of which plastics are composed, and on certain of the plastics themselves, would not have been placed months ago by the Office of Production Management (now War Production Board). And the many tooth brush manufacturers, the button makers, the shower curtain makers, the baby pants, belt and suspender manufacturers might have been left undisturbed in the peaceful pursuit of their commercial business as usual for a while longer. And think of the travel expenses which might have been saved by those molders of plastics who have been camping by the hundreds on the Bureau's doorstep in the past few months, with their plaints for urgent approval for Navy business lest they starve.

Emphatically, it is not more ideas about how to use plastics that we need. We already have too many ideas—what we are really short on is the material to use in those ideas. Not more fabricating capacity, but more raw materials for fabrication. The point I am trying to make is that you may be, with all good faith maybe and an intense desire to serve defense, pulling a "wrong-way Corrigan" on us; you are unintentionally, maybe, carrying the ball in the opposite field direction. This is not meant in criticism—it is expressed with one desire only, to be helpful.

Electrical equipment

If it would be of any assistance to you in fathoming the extent to which plastics, in one form or another, are being used in the Navy, it would be a very simple matter to start out with a good dictionary and, beginning with the "A"s, proceed down the alphabet until you yelled "uncle." There is, however, a much simpler way to sum it up. Suppose you take all the technical magazines and all the catalogs devoted to electrical equipment. Some of these books are two inches thick. One does not have to be an educated man—he can count with his fingers to learn that, for all practical purposes if it is not a plastics application in some form or another, then it is just not electrical.

Now you must realize that to find out what the Navy uses in the way of plastics, you have to take all those books and add to them a lot of other applications. Not subtract from, mind you, but add a lot that will not be in the books for some time. And that is only the electrical angle of the Navy. Need I go further?

Also you have no doubt heard a lot about "fifth columns" lately. Suppose I mention what column the plastics might fall into.

All electrical equipment just must have a conductor and/or conductive contact in it somewhere. So let us call the conductive element, common to any and all electrical apparatus whatsoever, the first column.

Now, the next all-important element in any electrical gadget whatever is that part which might be termed the harness of electricity. This element keeps the juice on its job and does not allow it to wander away from home. We call that element insulation. Find the electrical equipment today that does not make use of plastics in one form or another, or could not make such use to a decided advantage in its insulation element. So let us call the second element insulation. Therefore, in a great many cases we can call plastics a "second columnist" of electrical apparatus.

Now the third element in electrical apparatus, in point of frequency, is iron or steel for the magnetic circuit. This iron is the "third columnist," in the case of such equipment as involves a good magnetic circuit.

Finally, there must be something which ties together, in some one coordinated whole, the first, the second and the third columns. Let us call that general coordinator the framework. If weight is not important, this framework, box, shell, base or whatever you may call it, may be of steel or brass or other material of suitable strength and economical in cost. If weight is a consideration, then aluminum or magnesium are usually employed. But if one wants to conserve aluminum or magnesium one must look around.

The other metals are at least three times as heavy as aluminum. Only plastics are lighter—some of them almost exactly half its weight. So plastics could be, if they are the right ones for the job, this framework element. Plastics of this character could, therefore, be this "fourth columnist."

And most important of all, sometimes we are able to make the insulation, the "second columnist," in such a shape as to make it also the framework (base, box, etc.) to hold all other three elements together. So we can, we do, and we have, for many years past, employed electrical designs in which plastics serve at one and the same time as both the "second columnist" and the "fourth columnist." Is it any wonder that the button maker and the bottle cap maker are worried because the Navy has helped to take their material away from them?

So don't shout to us, "I've an idea." Rather, shout only when you have some material.

I think that one reason people do not seem to realize that the Navy uses plastics is that we do not refer to plastics as "plastics." Because we do not buy the materials for their own sake and under their own names. Instead, we call them something else. We may call them cable; and so every time we make a little change in cable, several million more pounds of plastics must be furnished. Or it may be we call them connection boxes or some other fittings made out of plastics instead of brass or aluminum. Or again, what do you think we had to go to instead of rubber when the Japs went into Malaya? In short, instead of calling these things plastics and glorifying them as materials, we call them cables, or connection boxes, or panel boards, or enclosures or a thousand and one other things, each of which denotes the name of an object and not the material of which that object is constructed.

This bring us up to the point of objectivity in specifications. We seek to achieve an object by one means or another, and we try to see to it that before one means of accomplishment gets critical or goes out one window, some other means of accomplishment is brought in through another window or through another door in time to keep the object itself going. We are not interested in materials, except as those materials may be fashioned into objects; and as those objects can be made to harness electricity, to drive a ship or to fire a gun.

To repeat, you may make plastics and think of them as plastics. But we don't buy plastics; we buy an object, or objects. Even better, we try to specify not merely an object but the service to be rendered by that object; and, as befits one of the branches of the armed forces, that service is something which must be achieved come fair weather or foul, ice or steam, shock or vibration, all without fail.

If you, as plastic manufacturers or molders, ask, "How do we fit in?" the answer is, "If you can provide materials of the quality and forms which can be made into specific devices or objects to serve naval purposes, all you have to do is to let that fact be known and "stand by for a ram." How do you make that fact known? Simply write a letter and say so. The Navy publishes specifications and descriptive information telling all about the testing procedures which must be gone through with in order to determine if your material is,

in fact, suitable for Navy purposes. All you have to do is request copies of these specifications, read them carefully and get in line with your offerings.

Specifications

You probably wonder how our specifications grow up. Not like Topsy, I assure you. It might surprise you how much patient testing and investigation, both of the materials available and of the jobs which those materials must do, go into the setting up of specifications.

Briefly, the Bureau's specifications start out with a survey of the conditions which actually exist in service aboard naval vessels—the conditions under which the equipment and the materials of which they are fashioned must operate. As only a few tests can be made aboard combatant vessels without great sacrifice of the effectiveness of those vessels in service, it is necessary to simulate, in so far as practicable, those service conditions in a naval laboratory.

This means that tests have to be devised which, while made ashore in a naval laboratory, will, nevertheless, give a sound indication of what can be expected to happen in actual service aboard ship. Ordinarily, this is a somewhat long and complicated procedure, because there is very little experience or background possessed by industrial establishments ashore that can shed much light on the subject. War vessels are a sort of closed book to most people, and rightly so. Outsiders just cannot be permitted to browse around at will on a combatant vessel, on a mere chance that they might, somehow, have something to offer if only they could find out what all the service conditions are.

The first step, therefore, in the development of a naval standard is not the development of a material itself, but rather the development of suitable test methods by which to judge materials. How would one know whether or not the materials were suitable, unless one put them to some searching tests? And how would one know what tests to put them to unless one had, somehow, simulated the actual service conditions? So it is obvious that what one must first have to start with is a good yardstick. One must have a good measure before one can tell whether anything is all wool and a yard wide.

The next step in the development of standards is to shorten up a long-time test so that it can be made in a reasonable length of time and yet tell the whole story. A test that takes 25 years to make is not worth much no matter how good it is. The test we are after and must have is one that can be made in 25 days or less, and at the same time can give us some indication of whether that material is going to last for 25 years. So the second step is making short tests out of long ones, and still keeping them good.

The third step, then, is to get hold of all of the materials, processes, devices and so forth which are available in industry, or in the minds of men, and have these all tested under exactly similar conditions, using the short time, long range test methods previously developed. At the conclusion of a series of such tests, we are finally in a position to know not only what industry has available for us that will work, but also whether it may be used as it is or if it must be modified. At that time, and not until then, do we begin to be in a position to match up our service requirements with the best materials and designs which are available to meet them. At that point, and not before it is reached, do we start setting up standards. Even then we start out as a timid soul dips his toe into cold water before taking the plunge. We call them "proposed" specifications at this point; put them up in a preliminary draft form and send copies far and wide. We consult Thomas' Register and all the trade magazines and technical journals, because we want to get as many good names and as wide a circulation as possible. We want to have everyone who has, or even thinks that he has, any possible chance of contributing to the technical progress at this point to have an opportunity of looking over everything which we have put down on paper.

After such preliminary specifications have thus been circulated to the industry, and to the services generally, things begin to happen. Everybody and his twin brother wants to know why we did this and why we didn't do that. This is very fine experience, because often times we do not ourselves know exactly why. But we do have to learn why in a hurry, or else back up. If we do know the answer to every question that is asked us, it is not difficult to convince the average person, who is a most reasonable sort of person once he learns that he isn't being kidded or being given the brush-off. If we do not know the answer, we soon have to start finding out. This may mean further testing, or even a change in test methods. It also means that not only are people checking up on us, but also that we are better able to check up on them, which makes it a very handy and educational thing all around.

Based upon this reaction from the industries and the shipyards, comments from our own laboratories and the complaints or advices from the service front, we proceed to amend and revise our printed draft. Obviously we have never yet reached that happy point where everybody agrees, so that we never do arrive at the point where we have a perfect standard. But it is a better standard than it otherwise could be, just because of all the different lights shed upon it. Now I know what you are saying, that this sounds very pretty and all that, but that we are in a war and nothing must stand in the way of our getting things out in a hurry. You are saying that this is all very well for peacetime, but that in wartime we must cut out the red tape. But I say to you, if that is the kind of red tape we should cut out, then who is smart enough to guess right the first time, and every time? Would you want to be on a ship built that way, or have your son serve on it?

Purpose of specifications

Do you realize that this so-called red tape is nothing more nor less than what is left in the pot after all of this boiling down process I have just described? It is the quintessence of that thought and the experience of many. It is several Gallup polls rolled into one. Do you realize that if we cut out any of that red tape we would be cutting out all the results of that research, all of that development, all of that give and take of discussion?

You have seen a scared chicken cross the road. You have slowed down your car and even swerved in order to miss him. But you couldn't, for he was too quick for you, so his feathers were left in your radiator grill work.

Why did that chicken cross the road? I'll tell you why—he never gave a thought to your car nor to whether or not he was on the right side of the road until the noise and the speed of your car excited him. Not having been trained to think beforehand, and it then being too late for him to learn to think, he acknowledged his dumbness and just acted. Too late to think, only time left to act. And what did it get him?

Even if he had been on the wrong side of the road to begin with, and even if the car was sure to leave the road, he still had one chance in two of not being hit. Even if the time was short, after he first heard your car, the thinking fast would

not have hurt him so much as the acting fast. But better yet, there was a time, before your car roared into sight, when he did have time to think. At that time he was calm, and his judgment might have been some good; no distracting roar and rush of wind.

The moral is—and it is not for chickens but applies to hurried ideas on plastics—most of our successful and large scale applications for plastics today were the result of thought and planning long before Pearl Harbor. It is never too late to think, but it is sometimes too early to jump. If we should, sometimes, be on the right side of the road, there may be no advantage in crossing to the other side just because of the roar and the wind.

Now to get back to plastics. Most of you have, no doubt, at one time or another, received some one or other of the Bureau's letters inviting you to submit whatever ideas you have had with respect to the adaptation of various plastic materials to naval needs. The usable suggestions have been surprisingly few in number, and most of them have followed a single pattern. The suggestions either concern things which we have been making use of in plastics for years, almost since the last World War, or which we have tried out repeatedly and could not make work. Even the parties making such suggestions did not know of any material which would make them work. That was left as our problem to solve. Sounds like a lot of people have been reading the newspapers.

My point in emphasizing this matter is that plastics have already reached that stage where it is useless for anyone to give us a pep talk on them. It is not so much a question of finding new uses for plastics, but rather it is a question of finding enough plastics, and the right kind of plastics, to meet the uses that already exist for them. Our main difficulty is one of finding plastics—i.e., of locating raw materials from which to produce anything like enough plastics for present naval needs, to say nothing of 1943 and 1944 or later.

Conclusions

If, therefore, I can leave a few very simple thoughts with you, I will not have wasted either your time or mine.

(a) First, stop whetting our appetites—we are already hungry. What have you got to eat?

(b) Second, if and when you can produce even better plastics, our defense appetites will have so grown by that time and so many new fields of application will have been found, that you will be in an even worse situation of trying to satisfy them in 1943 and 1944 than you are now.

(c) Thirdly, forget plastics as plastics, and think only in terms of the service which they can render in tough jobs. Give the subject many names, not just one.

Cut out the mystery, and the glamor and the charm. That was good sales talk when you had plastics to sell, and few wanted to buy. It is still all right for the magazines. But as for the war services, just let plastics grow up and mature; their service performance can keep them rolling from now on. If you have one that is new, or if you know of a new use to put one to, or even if you know only of a good method of testing one or of any other thing which will contribute to our more effective use of them, why not say so, simply and without glamor, tear shedding, flag waving or voice quaver—we are listening.

Again I should like to repeat, as a matter of emphasis, that the views expressed today are my own and not, necessarily, those of the Navy Department. Further, the personal pronoun "we" has been used in its strict editorial sense.

Government contracts

by ALBERT PHILIPSON*

TODAY one of the questions uppermost in the minds of most American manufacturers probably is "How can I get a Government contract?" This is a perfectly natural and proper question. It is not only permissible to seek government business; in some respects it is obligatory. As a result of the military program, an increasingly large percentage of civilian business will necessarily be curtailed or terminated. To remain in production many manufacturers will have to depend upon government contracts. Furthermore, the Government itself is almost as anxious to obtain the facilities of manufacturers to furnish its needs as the manufacturers are to obtain Government business.

My comments this morning concern primarily the procurement activities of the Quartermaster Corps. In general, however, the other purchasing agencies of the Government follow the same procedure as the Quartermaster so that these few facts will in essence pertain to other branches as well. Probably many of you know that the Quartermaster Corps is charged with the responsibility of feeding, clothing, equipping and transporting the Army and that it therefore purchases supplies which are used by two or more branches of the Army. It does not purchase specialized requirements of a particular branch of the Army. At present, therefore, the Quartermaster General's Office may be interested only in a few of the products which you men are producing. I believe that to date the only plastics which our office has been purchasing are helmet liners,[1] buttons, knife handles and a few others. The other branches of the Army may be using more plastics and the ever increasing need to find substitutes for scarce substances may result in the Quartermaster purchasing more of your products.

Securing information

The first question which any manufacturer interested in a Government contract asks himself is "Who buys what I can make? What branch of the Government is purchasing products like mine?" If you are familiar with the names and locations of field representatives of the Quartermaster Corps, or of any other branch of the Government, of course you may call in person or write to these local offices and obtain all the information you need. Should you be unfamiliar with local agents, you may write a letter addressed to Purchase Information Branch, Contract Division, the Office of The Under Secretary of War, Washington, D. C., listing the products you are presently manufacturing and asking the name of the division of the Army which may be interested in purchasing your article, and the address of the procuring office. In the Quartermaster Corps there are seven main procuring offices (or "depots" as we call them), each one buying different kinds of supplies. For example, the Jeffersonville Depot purchases, among other things, such items as leggings, tents, goggles, tableware; the Jersey City Depot purchases toilet articles, including combs and brushes; Philadelphia buys textiles, clothing, buttons, musical instruments, etc.

May I suggest when you correspond with either Washington

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[1] A complete discussion of the development and construction of the plastic helmet liner will shortly appear in a forthcoming issue of MODERN PLASTICS.

or a local branch office that you be as specific as possible in describing the article in which you are interested. Different varieties of a tool or machine or a supply may be purchased by several different branches of the Government. The more specific you are, the more helpful data you will receive.

Submitting bids

Having learned which office purchases your product, your next question, undoubtedly, is "How can I get the opportunity to submit a bid?" You may do so by writing to the particular depot which normally buys the products which you make and asking that your name be placed on the list which is maintained there of eligible bidders. Thereafter, when the purchase is to be made of such products, an invitation to bid will be mailed to you by the Purchasing Officer, listing the applicable specifications, stating the delivery points and dates, and furnishing all information necessary to enable you to calculate your costs and submit a bid.

In submitting your bids you will naturally be interested to know what your chances are of being given an award. In other words, you want to know, "How are the contracts actually awarded?"

May I point out to you gentlemen here that it is not necessary for any one wishing to do business with the Government to hire a paid agent to obtain business for him unless he wishes to do so. The Quartermaster General's Office prefers to do business directly with the contractor, and intermediaries are not necessary. If you have what the Government needs, and your prices are right, there is usually no need to pay anybody to get a contract for you. Incidentally, every War Department contract contains a written warranty by the contractor that he has not paid any contingent fee or commission to secure the contract.

Awarding of contracts

In awarding contracts, the normal procedure, and that which was used almost exclusively until about a year and a half ago, was to make purchases, after formal advertising for bids, from the lowest qualified bidder. Since the summer of 1940, however, the system of awarding contracts has been considerably altered. By an Act of Congress in July 1940, the War Department was permitted thereafter to make purchases without formal advertising in order to expedite the procurement of supplies essential to the war program. As a result of this and subsequent pieces of legislation, many restrictions on Government purchasing have been lifted, and the purchasing methods have been liberalized, in order to facilitate procurement of essential war requirements with the greatest possible speed.

At present when a comparatively small expenditure is involved and a short delivery time is permitted, the contracting officer in the field solicits bids informally either by telegraph or by letter, or even by telephone, communicating with as many, or as few, responsible bidders as is practicable under the circumstances. Most purchases, however, are made today by sending out written invitations for informal bids, to all known prospective bidders on the supplies desired. Normally at least fifteen days advertising time is permitted and the bids are opened at a specified time. However, they are not opened publicly, and awards are not necessarily made to the lowest bidder. Instead, based upon the bids received, negotiations are conducted with the bidders and contracts then executed with the successful bidders for quantities desired. This is all done at the procuring depots.

Price, frankly, is no longer the controlling consideration. In making awards under the "negotiated contracts" consideration is given also to such factors as prompt delivery, proper quality, effect of the defense program on consumers, the maintenance of fair labor standards by Government contractors, the avoidance of undue geographic concentration of contracts, financial responsibility of prospective contractors, and the avoidance of transportation congestion.

In September 1941, the President established what was then known as the Contract Distribution Division of the Office of Production Management. Similar organizations were then established in the Office of The Secretary of War and in The Quartermaster General's Office. The Under Secretary issued instructions to the Chiefs of the various Supply Arms and Services announcing a definite procurement policy of effecting the widest possible distribution of war contracts. To accomplish such wide distribution, awards are now distributed, as far as is practicable, geographically, either by states or by other geographical areas which the contracting officer deems appropriate, in proportion to the available capacity to produce the desired items. For example, if 3,000,000 tooth brushes were desired, and fifteen companies offered a total of 6,000,000, five in one state offering 5,000,000 and ten in a second state offering 1,000,000, the successful bidders in state No. 1 would be awarded contracts for $^5/_6$ of the 3,000,000, and those in the second state $^1/_6$ of the 3,000,000.

In order to spread awards among as many suppliers, in as many areas as possible, the maximum quantities awarded to any one bidder is limited by the contracting officer whenever such limitation does not jeopardize prompt delivery. Usually, "all or none" bids are rejected. We realize that this policy of wide distribution of defense orders entails, in many cases, increased costs; but speed, not cost, is the dominant factor today.

You men have heard it said, and I am sure you understand its significance, that "this is a war of production." To win such a battle of machinery, every existing piece of equipment in the country must contribute to the assembly line. In this fight there is no more room for an idle machine than there is for an idle soldier. Your Government, therefore, is trying to utilize as far as possible every existing productive facility in the land. To do so, and to afford every competent qualified manufacturer an opportunity to participate in the national war effort, the War Department has established a policy of encouraging subcontracting as far as is practicable. Every bidder who offers to subcontract the work is given favorable consideration. The small manufacturers are entitled to the same privilege of serving their nation as the big fellows, and by fostering subcontracting the Quartermaster is helping them to do their bit.

Despite geographical distribution and subcontracting, prices must nevertheless be reasonable. In many instances "ceiling prices" are established in the Quartermaster General's Office on articles to be purchased before bids are invited. These "ceilings" are not publicized and are used as a basis of making awards. If the bids are above the "ceiling" they are rejected. If necessary, informal negotiation is conducted with the bidders to bring the bids in line with the "ceiling price." These "ceiling" prices are determined in our office only after considering previous bids for similar articles, prices paid on previous purchases, the current price of raw materials and any indicated increases in labor costs. If, however, it is found on opening the bids that the "ceiling" does not conform with the trend of prices it may be modified accordingly.

In order to speed up the production of certain items the Quartermaster General's Office fre- (*Please turn to page 116*)

PHOTOS, COURTESY RCA MANUFACTURING CO., INC.

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Old records for new

Discarded phonograph records are a source of recoverable shellac if imports should be curtailed by the war

IN its more than 40-year battle to eminence, recorded music has approached the vanishing point three separate times. Each time it has come back stronger than ever. And now it is girding itself to fight off another possible attempt on its life at the hands of war.

The lines of communication which end in the phonographs of millions of American homes begin in the steaming forests of India. Along this route now lie uncharted dangers in many forms, as raiders and submarines spell death to peaceful shipping. So the phonograph record prepares once more to fight for survival.

RCA Victor is approaching the problem of the scarcity of shellac realistically by offering to buy up any and all quantities of old phonograph records which the attics and cellars of America can be made to disgorge. Purchased by the company through its dealers and distributors, the scrap records are being stored against the day when stocks of shellac, vital to the modern record, may dwindle.

A phonograph record is made of ten materials, of which the most important, in point of quantity, is shellac. This material is the purified form of lac, a resinous substance secreted by an insect which lives on certain trees in India. Transported to American shores, shellac is combined with the other ingredients, which come from other parts of the world, and prepared for pressing into the familiar form in which it is sold across the music counters of the world.

At present, a certain amount of scrapped records finds its way into the plastic compound as a filler. It makes an ideal binder, because it combines all the elements of the record itself, giving it important advantages over other type binders which would be less easily absorbed into the body of the plastic. Should the progress of the war cut off the supplies of shellac, it would be possible to conserve the adequate supplies now on hand by increasing the quantity of scrap material used in the plastic. Thus, the move to increase supplies of scrap, although current supplies appear to be adequate.

Making the plastic record

A modern phonograph record can be pressed from a shapeless lump of plastic in exactly 36 seconds, whether the finished product be Beethoven's *Fifth Symphony* or *Chattanooga Choo-Choo*. But that is far from the whole picture. Each phonograph record must go through five principal stages before it is ready for the market.

Contrary to popular conception, records are not made of wax. In fact, there is no wax in them. No rubber, either. They are compounded and treated from resins, shellac and various types of fillers in a formula that is constantly being improved. Actually there are two different disks which are referred to as "records" in the recording of music: one the plastic platter on sale in the music stores, and the other the studio disk on which the music or sound is first engraved.

The studio disk contains no wax either, but is a blend of substances which looks somewhat like soap. This is melted, centrifuged and poured through a very fine mesh to remove all foreign particles. It is then allowed to flow out smooth on a circular metal plate, ready for the studio. This process, too, is constantly undergoing improvement as newer and better ways are found. The company is currently testing a new type of recording disk which requires no metal plate, and which uses much less plastic material per disk.

The recording disk is the principal character in the studio control room, which is similar to those seen in radio stations.

(*Please turn to page 48*)

PARADE WITH MUSIC

Instinctively, man has always turned to music to lighten his tasks. The soldier sings as he marches, the woodsman as he swings his ax, the bricklayer as he wields his trowel. It relieves monotony—and it makes him feel good! Research has revealed that any worker's efficiency and morale reach low ebb near the close of the morning and afternoon work periods—the so-called "peak fatigue points." From a scientific standpoint, music is the ideal instrument for counteracting this work slump, because it acts physiologically on nervous control, circulation, digestion, metabolism, body temperature, posture and balance. To bring the benefits of music to workers in industrial plants, the factory broadcasting system has been developed, consisting of numerous loudspeakers hung from the ceiling at strategic points throughout the plant, and powerful amplifiers—altogether a giant version of the home radio. Music is furnished from a central point equipped with twin record turntables or an automatic mechanism. Successful application of music to industrial use depends upon a careful selection of compositions and the proper programming of them for the time of the day in which they are used. Most important time for music is, of course, at the peak fatigue points, although it need not be confined to these periods.

Tests conducted in England by the Medical Research Council show that industrial production "with music" has run from 6 to 11 percent higher than the same activity under identical conditions without the benefit of melody. A F of L President William Green calls music "a friend of labor, for it lightens the task by refreshing the nerves and spirit of the worker." William Bristol, of the Bristol-Myers Co., gives a businessman's point of view: "We believe that music, news and other types of informative and entertaining programs will help plant and office workers to do a good day's work with a minimum of fatigue." Such companies as the Botany Worsted Mills, the Curtiss-Wright Corp., Owens-Illinois Glass Co. and the Picatinny Arsenal, Dover, N. J., have already put music to work to help assure maximum efficiency in their war production efforts, and other companies are following suit almost daily. The production parade is marching to music!

1—The studio disk carrying the recorded music is taken to the factory, coated with a bronze powder and given a bath in silver. 2—In an electroplating tank, a copper shell (or master) is formed on the disk. 3—The recording disk is separated from the master, from which will be made the matrix—or the negative from which the commercial record is pressed. 4—The matrix is inspected for flaws after it has been trimmed and polished. 5—The "biscuit," or plastic from which records are made, is pressed and sheeted in a rolling machine. 6—Each square of biscuit, which makes exactly one record, is folded and rolled so that seams won't show in the finished record

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The disk is placed on a precision machine which revolves it at exactly the same speed (78 revolutions per minute in the case of home phonographs) as it will be turned when played back. A system of weights and pulleys is employed in place of a spring or electrically driven motor to assure that the revolving speed shall be absolutely constant. The familiar spiral grooves are cut by a recorder, with a sapphire cutting point, as the artists play or sing into the radio-type microphone. The sound waves are changed into electrical impulses which vibrate the cutting head as it travels its spiral path.

At this point it would be possible to "play back" the transcribed disk, but it could be done only once. The circular grooves, so carefully engraved, would be ruined for any further reproductions of the original sound. And so the next step in the manufacturing process is to use the disk as a mold in producing a "matrix," or negative of the original record, with tiny ridges corresponding to the disk's grooves.

This is accomplished through a refined technique of coating the entire surface of the compound with a film of silver or gold (both of which are of high electrical conductivity) and placing the whole in an electroplating bath. When the metal has formed on the disk in sufficient thickness, the compound is stripped off and the matrix is exposed.

At this point, it would be possible to use this duplicate to press out copies of the original record. But to do so would be unwise because of the danger of damaging it beyond repair. So the whole process is repeated, with minor variations, to produce another positive copy and then as many negatives as may be needed to supply the record presses. These final negatives of the original disk are used for stamping records, while the master is kept permanently in a special vault file. In the company's files at Camden are stored the recorded music of two generations as played or sung by the greatest artists of the time.

It is interesting to note that throughout the process required to obtain the final record stamping matrix from the original, the fidelity of the original tones and sounds is preserved intact. Constant research, which has improved recording and reproducing techniques, has not been idle in working for perfection in the manufacturing process.

With the completion of the final matrices, the time has come to introduce the "record biscuits" made of the plastic whose ingredients have come from all over the world. These materials have been weighed out into proper proportions, carefully mixed and converted into a plastic by the application of heat in closed milling chambers. The plastic is then rolled out into wide sheets, cut into wafers, or biscuits, and delivered to the press room.

The actual stamping operation is performed in a hydraulic press which, in a 36-second cycle, first heats and then cools the record biscuit under terrific pressure. The circular labels are not pasted on, as popularly supposed, but are actually pressed into the record material during the pressing process.

When the record is removed from the press, the only remaining steps are to round and (*Please turn to page 100*)

7—A hydraulic press stamps the record on both sides in a 36-sec. cycle of alternate heating and cooling under pressure. Labels are not pasted on, but pressed into the record's surface. 8—In the edging machine, the record's rim is smoothed with emery pads before it slides down the chute into the checking department. 9—Records are examined, polished with a soft cloth and slipped into envelopes for packing and shipping

PHOTO, COURTESY DOW CHEMICAL CO.

Good news for thirsty guests, individual ice cube cups for this new household refrigerator tray are quickly removed from the rack, permit release of cubes in a jiffy. They are drawn from a single sheet of ethyl cellulose

Frozen dozen

PRYING recalcitrant ice cubes from tightly frozen trays is a chore that has wearied the housewife, the convivial host and the refrigerator engineer alike.

To conserve time and current used in this fashion, a new unit, called the Sani Tray, has been developed by Swift Manufacturing Co. This consists of an enameled tin rack which holds twelve transparent plastic cups, drawn from ethyl cellulose sheet. Cups are filled in the usual way—by running water over the whole tray and then freezing—but cups can be removed individually without danger of the plastic sticking to the rack. A slight pressure on the sides or bottoms of the flexible cups permits ready extraction of the ice cubes without thawing the entire tray and without touching the cubes.

Convenient and sanitary, these fragile-looking cups are actually sturdy. They won't bend or break unless seriously abused. The material is tasteless and odorless and doesn't affect the ice itself. The advantage of the plastic cup over that first developed by the company, which was made of paper, is obvious.

Plastics were desirable because of their durability, color and ease of cleaning, but it was necessary to secure an economical product with extremely thin walls to permit a high rate of transfer, essential for rapid freezing. Recent developments in drawing thin sheet plastics indicated that this method might be adaptable. An ethyl cellulose sheet .010 in. thick was selected because of the extraordinary toughness, the deep draws possible and good rate of heat transfer. The material is not adversely affected by moisture, is said to resist severe handling at temperatures as low as 50 deg. below zero and can be immersed in boiling water. Additional production advantage is that the material can be drawn, crimped or worked into shape by other methods at normal temperatures. The advance in ice tray design and construction made possible by deep drawing technique and the plastic itself is valuable now, when household replacements of metal parts are at a premium; but its real significance is the lifeline to the post-war future it extends to refrigeration developments.

Credits—Material: Ethocel

Laminates and treated surfaces

PHOTOS, COURTESY FARLEY & LOETSCHER MFG. CO.

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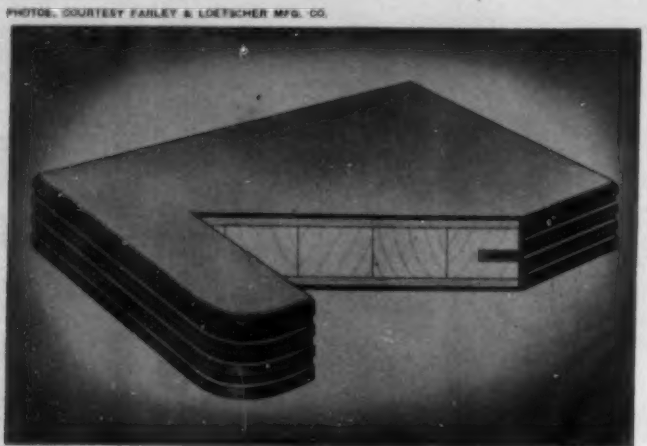

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THE vast increase in defense plant, factory, military and housing construction projects has created a lively demand for inexpensive, decorative, long-wearing materials for interior use. Second only to economy is the demand for rapid, simple installation—the time factor is as vital in construction as in military strategy. Peacetime installations of plastic laminates in large industrial establishments have a record of success. These laminates, coupled with new plastic-treated prefinished surfacing materials are creating tileboards in hospitals, factory washrooms, laundries, garages, food storage rooms; forming partitions for offices; making counters and table tops in restaurants, and on ships; covering desks in schools; and becoming handsome walls, panels and ceilings in homes and business places.

Since an army or a factory crew travels on its stomach, first call for laminates has been for mess tops in industrial and Army camp cafeterias. In defense plants particularly, which are frequently located at distances from facilities adequate to feed the workers, the establishment of large capacity dining rooms with durable sanitary equipment has been a necessity. Laminated plastic tops have proved to be the answer because their surfaces are hard, easily cleaned, will stand years of rough wear without deterioration in appearance, are non-porous, chemically inert, proof against spotting by acids and alkalies, and in some instances cigaret-proof.

Several manufacturers are producing laminates of this sort. Figures 3–6 show one type of laminated material which has been used in industrial plants and Army camps, on cargo and merchant ships in passenger staterooms, lounges and in

***1**—Cross section of laminated table top shows 5-ply, warp-resistant wood core with $^1/_{16}$ in. plastic surfaces veneered to both sides. **2**—A restaurant uses this material in black and white for tables, counters, ceilings, walls, booths and water fountain in the rear. **3**—Tan linen laminated factory cafeteria table tops harmonize with floor and walls. **4**—Cross section shows 7-ply wood-core between plastic veneers*

PHOTOS 3-6, COURTESY FORMICA INSULATION CO.

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crew quarters. Plastic laminated tops are built by veneering a $^{1}/_{16}$-in. laminated sheet onto the top layer of a piece of plywood, and then putting a sealing ply about $^{1}/_{32}$ in. thick on the bottom for the purpose of excluding moisture. This sealing ply is a necessary protection against warping. The character of the plywood used is important. It should be at least 5-ply and should have a smooth, tight-grained hardwood for the top surface. If a resinous wood is used, the resin in the wood will usually be unequally distributed; and when the wood and plastic veneers are put under pressure in the veneer press, only the fibrous parts of the wood will be compressed (the resinous spots will not be compressed), resulting in a top with many inequalities in the surface. "High spots" will take an undue amount of scuffing from the bottoms of dishes and the result will be that the top will soon show uneven wear. However, if a tight-grained, smoothly sanded top ply is used, wear will be evenly and slowly distributed, giving a top that can be depended on for many years of service without changing its appearance.

The edges of the tops are either finished with heavy extruded moldings (Fig. 4, top), or with a plastic matching or contrasting strip glued on their edges. Note the 7-ply core illustrated with the sealing ply on the bottom to exclude moisture. Figure 3 is an industrial cafeteria installation and Fig. 5 shows a corner of a schoolroom at Crow Island, Winnetka, Ill., with desk top of hardy laminate and body contour plywood chairs. Library and work tables throughout the school are surfaced with durable laminate.

Figures 1–2 illustrate two other types of plastic laminate created by a manufacturer of doors, windows, etc., which are used for table and counter tops, wainscoting and wall paneling. One is made in $^{1}/_{16}$-in. thicknesses principally of paper-base material treated with synthetic resins—phenol, melamine and urea-formaldehyde—and laminated under high heat and pressure. The plastic sheet is then cold-glued to both sides of a lumber core. The (*Please turn to page 102*)

PHOTO, COURTESY PARKWOOD CORP.

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5—*Teachers and students respect the laminated desk tops which take ink, paints and blows without whimpering. Note the posture-correct plywood chairs.* **6**—*Woven wood veneers fused with plastic surface a decorative fireplace panel.* **7**—*Colorful plastic-surfaced panels modernize the bath.* **8**—*Large plastic coated sheets rapidly and inexpensively applied over old walls renovate this lubritorium.*

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PHOTOS 7-8, COURTESY BARCLAY MFG. CO., INC.

Plastics in Review

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1 The old tin grater can be added to the scrap metal collection heap. Rust-resistant stainproof graters of clear plastic go to work in the kitchen. They're injection molded of Hercules cellulose acetate for Renwal Mfg. Co. Model and molds were made by Stricker-Brunhuber Corp.

2 Transparent light-catching stair and mezzanine balustrades of Plexiglas sparkle in the luxurious Joseph Shoe Salon. Twisted rods were machined and polished on woodworking tools; curved rods, heated and formed in a special jig. Both were attached to upper and lower stair rails by triangular acrylic blocks. Designed by Frank J. Lapasso and fabricated by Industrial Arts, Inc.

3 Sink, work surfaces and splash-back on this modern cabinet are all trimmed with cellulose acetate molding. Easy to install, handle and keep clean, this architectural molding is available in H, Y and J shapes for inner and outer corners, for interlocking edges, and in one color or with contrasting inserts. Extruded from Lumarith by R. D. We.ner Co., Inc. This combination sink and cabinet is now traveling on display with America's Modern Plastics Exhibition

4 War industry workers or home craftsman will welcome the handy, pocket-size case, molded of durable cellulose acetate, which houses the Brownie 6-ft.-plus steel tape rule. It is injection molded in two halves which are cemented together. Waterbury Button Co. molds it of Tenite for Master Rule Mfg. Co., Inc. The smooth surface resists oil and moisture, cleans easily

5 Silent-operating Celoron small truck wheels are easy on floors, tough and resilient. They're made of molded-macerated, phenolic-impregnated fabric and are especially valuable in the chemical industry because the laminated plastic resists acids, alkalies, oils, etc. These are for Lewis-Shepard hoist trucks, but wheels are made in standard sizes ranging from 3 in. to 12 in. in diameter

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6 Maximum light diffusion, light weight and a minimum of breakage is achieved with plastics in the Excelux fluorescent luminaires by Edwin F. Guth Co. Translucent ends of Bakelite polystyrene replace the cast aluminum ends originally used to support the center glass shield. Shipping and handling costs have been lowered

7 A mite among the mighty, the molded cellulose acetate pencil tip is a tiny unit but the total potential metal replacement it permits represents a saving of approximately 500,000 lb. of brass rod in the two million tips used yearly by the pencil industry. It's injection molded of Nixonite, based on Hercules cellulose acetate flake by American Improved Products, Inc. Used by Salz Brothers

8 Sturdy molded phenolic spools for tungsten wire not only release aluminum but also effect a production cost reduction of 20 percent. Spools are molded in two sections which fit together tightly but are cemented to insure a permanent bond. Universal Plastics Corp. molds them of Bakelite for Callite Tungsten Corp.

9 There's a new red lid on Knapp-Monarch Co.'s thermal food and beverage jug. This heavy-duty phenolic closure, molded of Durez, is about 1 in. deep and 3 in. in diameter. It's tasteless and odorless, will stand rough service without losing color or finish

10 Double Borkite cellulose acetate strip shields mask fluorescent tubes, softening glare and diffusing light with a minimum light loss. They're drawn from Lumarith sheet stock by the "Fourth" method, developed by General Plastics Co. Made in lengths of 24 in. (left) and 48 in. (right), they are light and pliable. Easily installed, they snap directly on the tubes and are ideal for strip lighting in single continuous lengths or two-tube strips

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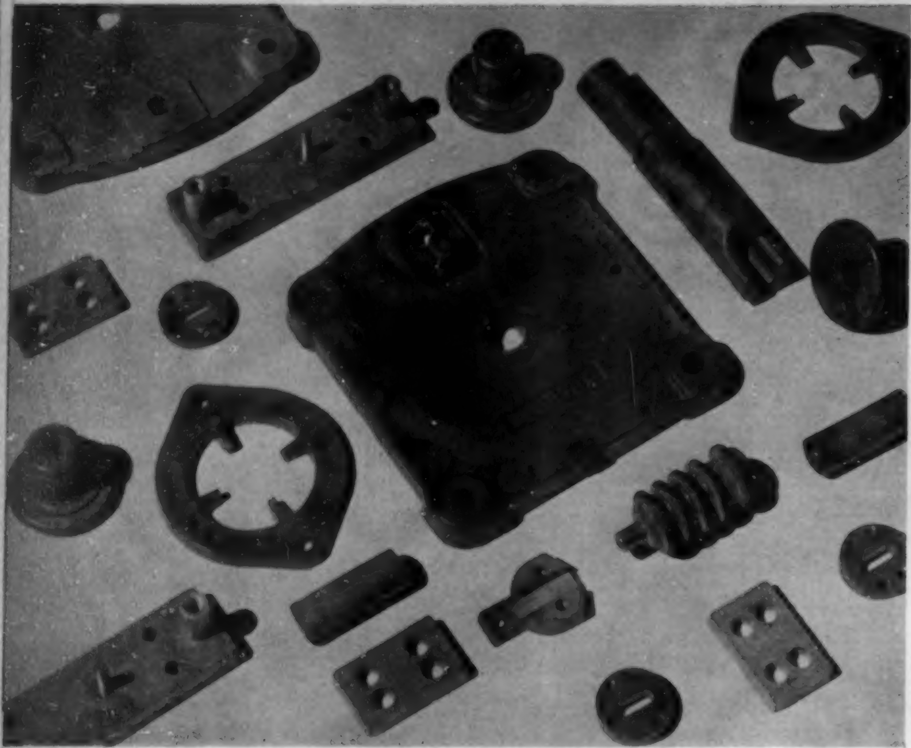

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Injection-molded Mycalex

by T. N. WILLCOX*

IT is a poor commentary on human nature that war is necessary to inspire engineering progress. World War I promoted the rapid rise of radio, aircraft and the automobile. But it has taken two World Wars to bring the material described in this paper into an important position in the technical world.

At the end of World War I, an English patent was issued covering the molding of Mycalex, an electrical insulating material made of ground mica bonded with glass. Good radio frequency characteristics, temperature resistance and arc resistance promised an immediate future. Yet for 20 years no great strides were made. The material cost too much for the relatively simple shapes in which it was available.

Until recently, all of this insulating material had been compression molded by forming the heated material under pressure between a mold cavity and plunger. Now, as a result of technical advances, the material can be injection molded by squirting it into a closed cavity under pressure. No longer impossible are such things as long molded holes, thin-walled parts, delicate inserts and close tolerances. Injection molding is doubly significant, making complex shapes in this inorganic plastic available at the crucial moment.

The properties of the material can best be appreciated by studying existing applications. Watertight terminal seals for electrical heating units have been used for a number of years. Brushholder insulation for DC traction motors requires arc-resistance as well as heat-resistance. Aircraft sparkplug connectors must withstand acid exhaust fumes without arc-over. Radio-transmitter terminal boards, tube sockets and coil forms all require high dielectric strength, low power factor, low dielectric constant, low loss factor and low water absorption.

Relatively high thermal conductivity assists the distribution of heat away from "hot spots," helping further to prevent arc-over, thermal distortion or dielectric breakdown. If an arc-over does occur, the path established by the arc becomes non-conducting again after the material cools down to normal temperature. Finally, it should be pointed out that metallic inserts can be molded into this material, a feature entirely impractical with any fired ceramic.

Outstanding properties of the material can be summed up:

1. Heat resistance
2. Arc-resistance
3. Low water absorption
4. High dielectric strength
5. Low loss factor
6. Good mechanical strength
7. Use of inserts

To all these, injection molding adds:

8. Intricacy of molded parts
9. Good dimensional tolerances

Because this material is not like any ordinary plastic material, many lessons had to be learned before intelligent rules could be made for designing new parts. The following "Do's and Don'ts" will be of practical assistance to the designer of injection-molded parts made of the insulating material. These rules, like all others, have their exceptions.

A. Blind holes can be molded (*Please turn to page 118*)

* Mycalex Engineer, Plastics Division, General Electric Company.

1—*A group of intricate electrical parts injection-molded of an insulating material composed of ground mica and a specially developed glass. Metal inserts can be molded in.* 2—*The same material forms terminal seals for Calrods which are also injection-molded.* 3—*Effect of water on power factor tests on $^{1}/_{4}$ in. thick Mycalex*

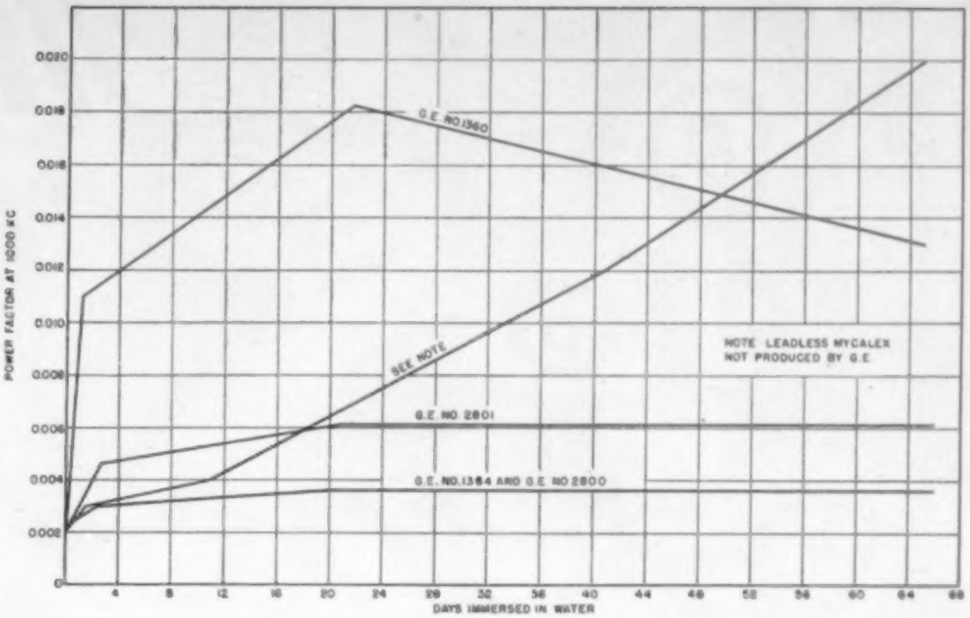

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TABLE I.—COMPARISON OF PROPERTIES OF COMPRESSION-MOLDED AND INJECTION-MOLDED MYCALEX

Properties	*Mycalex compression molded* *No. 1360 general-purpose*	*No. 1364 radio grade*	*Mycalex Injection-molded* *No. 2800 radio grade*	*No. 2801 general-purpose*
Electrical				
Power-factor (1000 Kc.)			See Fig. III	
Dielectric constant (1000 Kc.)	8.3	7.5	7.5	8.5
Dielectric strength (volts per mil. 25 C. for 0.2 in. thickness) 25 C.	340	360	380	325
100 C.	340	...	...	...
Resistivity (25 C.), ohm.-cm.	5×10^{15}	...	...	...
Arc resistance, seconds*	325	260	260	325
Mechanical				
Traverse strength—modulus of rupture, lb. per sq. in.	15,000–20,000	14,000–19,000	8000–10,000	10,000–13,000
Tensile strength—lb. per sq. in.	5000–7000	...	...	...
Compressive strength—lb. per sq. in.	22,000–30,000	...	...	...
Resistance to impact—ft.-lb. (Charpy—$^{3}/_{4}$ in. diam. rods)	1.16	...	.10 Spec. 5 in. × $^{1}/_{2}$ in. × $^{1}/_{8}$ in.	.12 Spec. 5 in. × $^{1}/_{2}$ in. × $^{1}/_{8}$ in.
Hardness—Scleroscope	40	...	...	...
Brinell	40–50	...	...	...
Mohs scale	3–4	...	...	...
Physical				
Water absorption (48 hr.)—percent	.03	.003	...	...
Heat resistance—deg. C.	300	325	325	300
Thermal conductivity (Btu. per sq. ft. per in. thick per hr. per deg. F.)	3.95	...	...	...
Mean specific heat (g. cal. per g. per deg. C.)	.2 (40–650 C)	...	...	...
Coefficient of linear expansion (per deg. C.)	8×10^{-6}	...	...	...
Density—lb. per cu. in.	.124	.106	.106	.124
Specific gravity	3.44	2.95	2.95	3.44
Color	Gray	Gray	Gray	Gray
Surface	Hard, slightly rough	Very hard, very smooth	Hard, very smooth	Very hard, very smooth

* A. S. T. M. Method D495-38T.

All-America

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THE perfect package should combine utility and good looks in such proportions that one does not detract from the other. In this group of winners in the Eleventh All-America Package Competition, sponsored by Modern Packaging magazine, the ingenious use of plastics contributes to both halves of the ideal combination. Their application in the eight awards pictured here is no less interesting because critical plastics are gradually being withdrawn by the exigencies of war from the packaging field.

As a matter of fact, it was evident in the 1941 Competition from the decrease in the use of plastics (as compared to previous years) that many packaging and display programs had already felt the pinch of shortages and were turning to less strategic materials. The many dramatic ideas and unique services which plastics offered in the past have been shelved for the duration.

1—The emphasis placed upon vitamins by the medical profession and dieticians and their increased use by the public, focus interest in a point-of-sale vitamin products display. The cabinet made for Abbott Laboratories has a metal frame and base dramatized by a translucent molded cellulose acetate dome and fluorescent plastic letters. The box-like dome measures 12 in. tall, 8 in. wide, 4⅝ in. deep at the bottom and 1⅜ in. deep at the top, and is illuminated from the rear. It's injection molded of bright yellow Tenite by American Molded Products Co. A built-in flasher produces a strikingly colorful appearance and directs attention to the sign "Abbott" which is in red transparent cellulose letters set atop a black plastic plaque. The Rx symbols on small shields on both sides of the unit are formed from Monsanto's fluorescent plastic.

2—Spilt ink, one of the minor tragedies of schoolroom or business office, is a problem on which ink manufacturers have been working for years. To prevent such accidents W. A. Sheaffer Pen Co. has combined ink-resistant injection molded and extruded plastics in a new pour-out closure for pint and quart Skrip bottles. Since these larger bottles are used mainly to refill smaller containers, they were designed to afford firm grip and deliver a steady stream controlled entirely by tipping the bottle. Plastic parts in the pour-out are: a molded body by Injection Molding Co.; spout cap molded by Owens-Illinois Closure Division, and an extruded vent tube by Plax Corp.

Probably one of the largest volume outlets for plastics in the packaging field has been in the form of closures; stock caps of every description or special closures in dainty pastels and vivid shades have added glamor and distinc-

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winners use plastics

tion to whole families of cosmetic, food, drug and other lines, as may be seen in the next four package groups.

3—The Yardley travel beauty kit carries week-end necessities and beauty preparations. The latter are topped with colorful closures decorated with a tiny bee hovering over a flat petalled surface. Designs are molded-in. Armstrong Cork Co., Closure Division, is the molder.

4—Clean white plastic closures carry out the look of wholesome freshness which characterizes the cheerful cosmetic products of Milkmaid, Inc. Closures are by Armstrong Cork and Victor Metal Products Corp. The rouge container is made of plastics by A. J. & K. Company.

5—Old South Perfumers reproduce practically authentic replicas of old pieces of the ante-bellum period, with bottles brought up to date by ivory plastic tops. Conical fluted closures for perfume and cologne decanters and the plain lotion bottle are molded by Phoenix Metal Cap Co. Shaker top for the talcum powder container—a reproduction of an old Sheffield muffineer—is by Owens-Illinois.

6—Sharp and Dohme, Inc.'s, array of flat-sided Spasaver pharmaceutical bottles depends upon sturdy chemical-resistant caps, molded by Armstrong Cork, to prevent dripping. Each cap covers the lips and thread of the bottle, assuring a clean pouring surface.

7—This tamper-proof shoelace dispenser and counter display, made for Hutmacher Braiding Co., is a two-time winner, as it received a Top Award in the Sixth Annual Modern Plastics Competition. It consists of a metal chamber with 18 divisions covered by a transparent Vuepak dome. At one section of the plastic dome is a triangular opening. By turning the dial handle on the center of the dome, the triangular opening can be revolved to any compartment and a pair of laces obtained from it. Then the cover is released, so that it may return to its original position, thus keeping the display free from dust or pilfering. Center dial handle, the wedge-shaped section above it, and the opaque, red-lettered, ivory headpiece are formed from plastic sheet.

8—An all-plastic chest which doubles as a counter display is the unique prize-winning entry of International Silver Co., makers of 1847 Rogers Bros. silverplate. The molded phenolic base, of black Durez, has a hood of rigid transparent Vuepak which allows the customer full view of the silver, yet keeps the latter clean and saves it from the fingermarks of the curious. Brackets molded of transparent Crystalite hold the silverware in place without blocking the view. Cover is fabricated by P. P. Kellogg Co. and base molded by Northern Industrial Chemical Co.

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Stock molds

SHEET ONE HUNDRED-EIGHTEEN

Manufacturers can find handles of good design from stock molds without mold cost—subject to restriction on raw materials. Address Modern Plastics, Stock Mold Dept., Chanin Building, New York, giving item and sheet numbers

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1411. Coat and hat hook; base 2 5/8 in. long; 7/16 in. wide. Top hook 2 1/4 in. long; lower hook 1 3/8 in. long. Two screw openings

1412. Octagonal knob; 1 1/8 in. top diameter; 15/16 in. long. Inlaid metal strip across top; 1/8 in. diameter opening for metal screw

1413. Plain, octagonal knob. 1 1/8 in. diameter at top; 15/16 in. long; 1/8 in. diameter opening for screw

1414. Ridged, rectangular knob; 7/8 in. wide; 7/8 in. long; 3/4 in. deep. Has 1/8 in. diameter opening for metal screw

1415. Hemispherical utility rack; 4 1/4 in. long; 3/8 in. wide. 1/2 in. deep at center. Has 3 metal hooks; opening at either end for screw fastening

1416. Drawer pull 2 7/8 in. long; 9/16 in. wide; 1/2 in. sq. base either end; 1/8 in. diameter opening each end for screw. 1 3/4 in. distance between ends

1417. Drawer pull 3 7/8 in. long; 9/16 in. wide; base either end 13/16 in. by 1/2 in. 1/8 in. diameter openings for screws at each end. 2 1/4 in. distance between ends

1418. Door stop 2 3/8 in. long; 2 5/8 in. long with rubber tip. Shaft is ridged. Screw end 1/2 in. diameter

1419. Drawer pull with 1/8 in. wide inlaid metal strip. 15/16 in. long. Base at either end 5/8 in. by 1/2 in. Openings for screws 1/8 in. diameter

1420. Drawer pull with 1/8 in. inlaid metal strip. 3 7/8 in. long. Each base measures 13/16 in. by 1/2 in. Screw openings 1/8 in. diameter. 2 1/4 in. distance between ends

1421. Drawer pull with 1/8 in. wide inlaid metal strip. 5 in. long. Each base measures 15/16 in. by 5/8 in. Screw opening each end 1/8 in. diameter. 3/8 in. distance between ends

Note: Restrictions on supplies of raw materials may possibly limit production of some of these stock items. Please check with molders as to quantities available.—ED.

Reprints of all stock mold pages which have been published to date, with a complete index of suppliers, are available to Stock Mold Service subscribers

All molders are invited to submit samples from stock molds to appear on this page as space permits

Acrylic resins for dentures*

by W. T. SWEENEY, G. C. PAFFENBARGER and J. R. BEALL†

EVER since dentistry achieved a professional status there has been a constant search for a denture base of lifelike appearance that would not deteriorate in service. For nearly seventy-five years rubber was the most satisfactory material available. Cellulose nitrate plastic, also used during this period, had a more pleasing initial appearance than rubber, but soon warped and discolored and consequently was unsatisfactory. Shortly after World War I (1920), the synthetic resin industry began to furnish organic materials which were utilized as denture bases. Practically all of these materials were very inferior to rubber even though they were more natural looking. Consequently dentists, much to their embarrassment and their patients' discomfort, were constantly encountering failures of these dentures in service. While it is admitted that laboratory tests of plastics should be supplemented by practical tests, it is also certain that suitable laboratory tests would have forewarned the profession that these newer materials did not have the inherent properties necessary to make a satisfactory denture.

It is believed that any plastic which is offered for use as a denture base should first be given the tests described in this paper and compared with other materials which are known to give satisfactory service. Its dimensional stability, strength, color stability, hardness, water sorption, working properties and so forth should be compared with those of other materials tested under the same conditions. This report gives the results of an investigation in such a manner that a direct comparison of each property of the materials can be made, and also shows how the properties of both practical and experimental dentures can be determined in a quantitative manner. The published specification,[7] which gives a description of tests and requirements which a denture material should meet to be considered satisfactory, is based upon the data presented here.

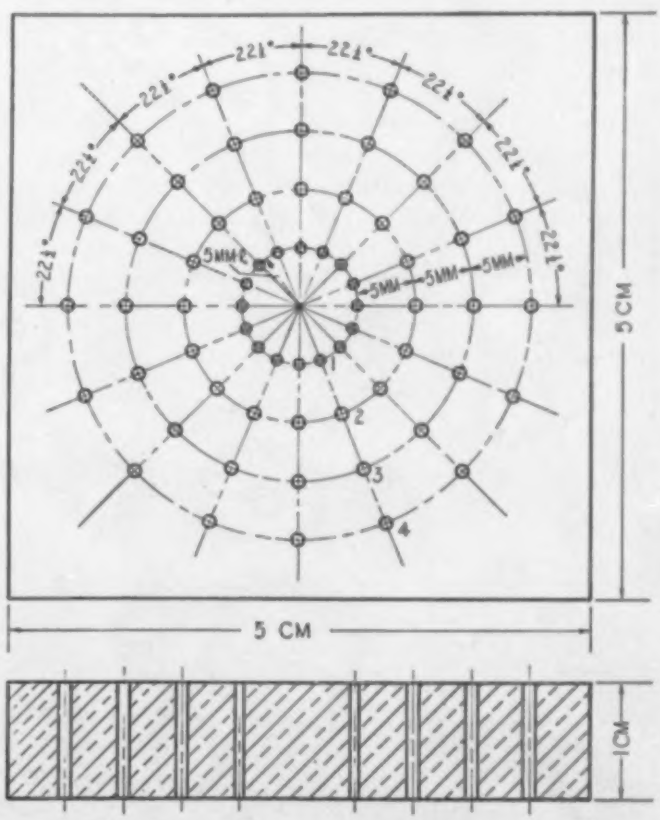
Materials investigated

The materials reported upon are listed in Table I and are representative of those sold in the trade at the time of purchase. This classification is based upon the general information available to the authors and not upon chemical analyses. Other materials than those containing acrylic resins are included for comparison.

Properties of uncured resins

Forms of materials. Acrylic resins are supplied for dental use as a powder, as a plastic cake and as a powder and liquid which are mixed to form a plastic cake. The material when used in the form of powder is packed and pressed in such a way that the particles weld together at elevated temperatures. The plastic cake and powder-liquid forms are cured under controlled conditions of temperature and pressure so that the polymerization of the resin takes place in the dental flask. The end products should be essentially the same regardless of whether the powder, powder-liquid or plastic cake is used. Heating the powder (polymer) tends to reverse the chemical reaction and converts part of the powder back to the monomeric (unpolymerized) state during the time the heat is applied. If the processing is skillfully done it will be difficult, if not impossible, to detect which of the three types of raw products (powder, powder-liquid or plastic cake) was used to produce the dentures.

1—Brass die for packing test of denture base material as described. Holes in inner circle (1) are 0.75 mm. (0.029 in.) in diameter; use No. 69 drill. Those in circles 2, 3 and 4 are 1.00 mm. (0.040 in.) in diameter; use No. 60 drill



* Abridged from a paper presented before the American Dental Association and published in the Journal Am. Dental Assoc., January 1942.
† Research Associates of the American Dental Association at the National Bureau of Standards.

Trade brand name	Type	Manufacturer or distributor
TABLE I—DENTURE MATERIALS INVESTIGATED		
DENTAL METHYL METHACRYLATE RESINS		
Acralite	Powder-liquid; pink	Acralite Co., Inc., New York, N. Y.
Crystolex	Plastic cake; pink	Kerr Dental Mfg. Co., Detroit, Mich.
Crystolex	Powder-liquid; pink	Kerr Dental Mfg. Co., Detroit, Mich.
Crystolex	Powder-liquid; clear	Kerr Dental Mfg. Co., Detroit, Mich.
Densene	Powder-liquid; pink	Cosmos Dental Products, Inc., New York, N. Y.
Livetone	Powder-liquid; pink	Precision Laboratories, Kansas City, Mo.
Lucitone	Plastic cake; pink	The L. D. Caulk Co., Milford, Del.
Lucitone	Powder-liquid; pink	The L. D. Caulk Co., Milford, Del.
Lucitone	Powder-liquid; clear	The L. D. Caulk Co., Milford, Del.
Nu-Tek	Powder; pink	Nu-Tek Company, Toledo, Ohio
Vernonite	Plastic cake; pink	Vernon-Benshoff Co., Pittsburgh, Pa.
Vernonite	Powder-liquid; pink	Vernon-Benshoff Co., Pittsburgh, Pa.
Vernonite	Powder-liquid; clear	Vernon-Benshoff Co., Pittsburgh, Pa.
INDUSTRIAL METHYL METHACRYLATE RESINS		
Lucite	Sheet	E. I. du Pont de Nemours and Co., Arlington, N. J.
Plexiglas	Sheet	Rohm & Haas Company, Philadelphia, Pa.
ACRYLIC-STYRENE RESINS		
AcRil	Powder-liquid; pink	AcRil Dental Corporation, Elberon, N. J.
ACRYLIC-VINYL RESINS		
Exelon	Blank	American Hecolite Denture Corp., Exelon Division, Portland, Ore.
Exelon	Powder-liquid; pink	American Hecolite Denture Corp., Exelon Division, Portland, Ore.
Luxene No. 44	Plastic cake	Luxene, Inc., New York, N. Y.
CELLULOSE COMPOUNDS		
Cellanite No. 60	Blank	Avalon Chemical Products Co., Los Angeles, Calif.
Crystalite	Powder	Coralite Dental Products Co., Chicago, Ill.
Hecolite	Blank	American Hecolite Denture Corp., Portland, Ore.
Parfait R	Blank	The Parisien Chemical Co., Toledo, Ohio
Parfait X	Blank	The Parisien Chemical Co., Toledo, Ohio
RUBBER		
Ash's dark elastic	Plastic sheet	Claudius Ash Sons & Co., Irvington, N. J.
Ash's gum pink	Plastic sheet	Claudius Ash Sons & Co., Irvington, N. J.
Herakles	Plastic sheet	Atlantic Rubber Mfg. Corp., New York, N. Y.
McCormick's 8A	Plastic sheet	E. J. McCormick Rubber Co., Inc., Ridgefield Park, N. J.
Traun's light pink	Plastic sheet	Atlantic Rubber Mfg. Corp., New York, N. Y.
S.S.W. pink denture B	Plastic sheet	S. S. White Dental Mfg. Co., Philadelphia, Pa.

Satisfactory dentures can be made from any of the three above-mentioned forms of material. The form which the dentist purchases should be governed by his available equipment and his working conditions. Special equipment is required to process the powder. The powder-liquid type requires attention to details of proportions of powder to liquid, time of mixing and packing. The factors to be considered in the selecting of the plastic cake are: 1) Distance from the supply; 2) transportation facilities; 3) temperature; 4) amount of material used; 5) frequency of use; 6) available storing conditions, because the ready-mixed gel has a short shelf-life at ordinary temperatures.

Comparison of monomers (liquids). In order to determine differences between the liquids furnished with denture base materials and a sample of commercial methyl methacrylate monomer, the refractive indices and boiling ranges were measured. The boiling range was determined by distilling 30 ml. of the liquid at a pressure of 85 mm. of mercury. The fractions of the sample distilled were estimated visually, the middle fractions being considered more accurate for comparison than the end fractions.

The data (Table II) show that all the samples, except Vernonite and AcRil, had about the same index of refraction and boiling range as the sample of commercial monomer. The Vernonite liquid was most viscous of all as it contained approximately 8 percent of polymer, which probably accounts for its slightly higher index. AcRil had a much higher index and boiling temperature than any other of the liquids. It is understood that this is styrene monomer. The other liquids appear to be almost entirely methyl methacrylate monomer.

Shelf-life. The stability of the material at temperatures and conditions found in dental laboratories and in transportation is important because materials which require special care to prevent them from curing prematurely or otherwise deteriorating under handling conditions are unsuitable for dental use and cannot be expected to have as uniform working qualities as those not affected by storing conditions. The plastic cake (gel type) has a short serviceable life unless stored at low temperatures. It may be used for several months if placed in a refrigerator at about 5 deg. C. (41 deg. F.) in a light-tight, hermetically sealed container. The polymerization is accelerated by oxygen, light and heat, so the storing conditions should be such that the cake is protected.

Resin in the powder-liquid form is satisfactory for use after several months' storage at room temperature. In fact some samples of methyl methacrylate powder and liquid stored for two years in a room at 20–30 deg. C. (68–86 deg. F.) were quite satisfactory. Thus it is evident that the powder-liquid form is being produced with a long shelf-life. The material furnished as a powder is, of course, already polymerized and has therefore an indefinite shelf-life.

Packing test. The plasticity of the resin is a very important factor in its successful use as a denture base. The material should be sufficiently plastic at the packing temperature to conform to the denture mold without excessive pressure being necessary. The very stiff materials require pressures which distort the flasking plaster, displace teeth and fine wires, and so introduce inaccuracy of detail.

The packing plasticity was determined by placing an 8-gm. sample of the resin on a brass block containing small holes (Fig. 1) and applying a 5000-gm. load to the specimen at 65 deg. C. for 10 minutes. This will cause the resins to intrude into the small holes. Soft materials will intrude farther than hard ones. A material which packs satisfactorily will pass into the holes to a depth of 0.5 mm. or more.

Table II—Refractive Index and Boiling Range of Liquids Furnished with Denture Base Materials

Material	*Refractive Index*[4] *20° C. (68° F.)*	*Boiling range at 85 mm. mercury pressure, deg. C.*[1] *Fraction 0*	*Fraction 1/4*	*Fraction 1/2*	*Fraction 3/4*	*Fraction 9/10*
Commercial monomer (duPont)	1.4142	40.9	41.9	43.4	46.2	48.3
Acralite[2]	1.4137	41.1	41.4	42.8	45.7	49.0
		40.9	41.9	42.7	43.6	45.5
AcRil[2]	1.5455	76.4	77.8	77.8	77.8	78.0
		76.0	76.0	76.5	76.8	77.8
Crystolex[2]	1.4138	41.6	42.0	42.2	42.4	42.5
		41.0	42.1	42.4	42.9	43.2
Densene	1.4141	41.0	42.0	42.2	42.5	43.0
Livetone	1.4141	..	..	..	..	..
Lucitone	1.4132	42.0	42.3	42.5	42.6	42.6
Vernonite[2]	1.4201	40.5	42.1	42.3	42.7	44.1[3]
		40.1	41.0	41.5	42.0	41.0[3]

[1] Thirty ml. specimen was used. Fractions were estimated.
[2] Results of two determinations of the boiling range are shown.
[3] Approximately 8% polymer residue was left after test.
[4] Refractive index was measured on Abbe refractometer to ±0.0002 except that of AcRil which was measured on Spencer refractometer to ±0.0005.

Cured resins

Preparation of specimens. All the specimens were cured in a Hydrocal plaster mold[4] according to the manufacturer's directions unless otherwise noted. Figure 2 shows a cured blank along with transverse strength specimens cut from a similar blank. These specimens (2.5 by 10.0 by 65 mm.) were machined to a tolerance of ±0.03 mm. in width and thickness as specified[8] for this type of material. All the specimens used in transverse testing were stored and tested at mouth temperature, i.e., 37 deg. C. (99 deg. F.). A few specimens were placed in air at 32 percent relative humidity for varying lengths of time. Others were immersed in water from 2 days to 6 weeks before being tested, the 2-day period being the standard time used. The round disk (E in Fig. 2) is the type of specimen used in determining water sorption and change of weight after immersion in water.

Chemical properties: Water sorption or imbibition. The sorption of water by denture resins affects their mechanical properties. The resins when wet are more flexible and weaker in transverse strength than when dry. Resins and other organic materials which are used to make denture bases show considerable variations in the amount of water taken up when immersed (Table III, column 3). These data obtained from tests made according to the A.S.T.M. method,[9] are expressed in terms of milligrams per square centimeter of surface. The sorption of methyl methacrylate resins varied from 0.45 to 0.60 mg./cm.^{2}; while that of the acrylic-vinyl copolymers was less than one-half this value, ranging from 0.15 to 0.25 mg./cm.^{2} The acrylic-styrene copolymer fell between these with a value 0.50 mg./cm.^{2} Rubbers used for denture bases gave values as low as 0.15 mg./cm.^{2} The cellulosic materials were, in comparison with the other materials, extremely high in water sorption, some specimens being as high as 6 mg./cm.^{2} At 25 deg. C. (77 deg. F.) the methyl methacrylate resins are higher in water sorption than either vulcanite or the vinyl-acrylic copolymers, but much less than the cellulosic denture materials. The commercial methyl methacrylate (sheet Lucite and Plexiglas) had about the same value (0.55 mg./cm.^{2}) as the resin sold for use as denture bases. The effect of water sorption on the dimensions of dentures will be discussed later.

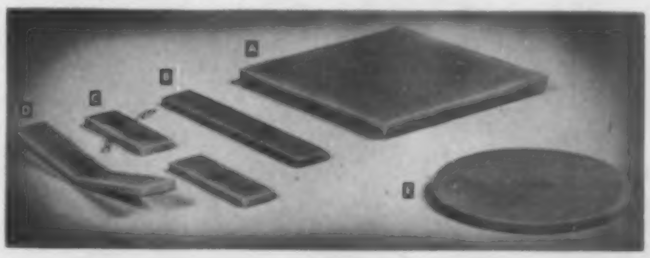
The high water sorption of methyl methacrylate resin may have been one reason for its not being used earlier as a pink base material, because it had been generally assumed that a high water sorption was associated with fouling of dentures, but clinical experience has shown that methyl methacrylate resin dentures remain unusually clean in service.

Solubility: The "solubility" or, more properly, the net change in weight of the disks used for the water sorption test are reported in Table III, column 4. The specimens were conditioned at 50 deg. C. (120 deg. F.) in air for 24 hours, then weighed dry. Subsequently they were stored in water for 24 hours at 25 deg. C. (77 deg. F.), then reconditioned as before and reweighed. The change in weight expressed in percentage of the original weight was recorded. The loss was very small for all the acrylic resins tested, being less than 0.1 percent. The cellulosic materials showed very high losses, ranging from 0.33 to 1.36 percent. In a few cases the specimens weighed more after than before, which indicates that some of the absorbed water was not lost in the final conditioning. The cellulosic materials were the only ones which lost sufficient soluble matter to have any practical significance from the dental standpoint.

Mechanical properties. The density, hardness and deflection in transverse testing of samples of several denture base materials were determined. The values for these properties which are significant in judging the ability of a denture resin to give satisfactory service are given in Table IV.

Density. The apparent densities of the materials were determined by weighing specimens in air and in water. The specimens were disks 50 mm. in diameter by 3.2 mm. thick (Fig. 2). The methyl methacrylate resins showed no significant differences in this property. Their range of density was only from 1.16 to 1.18 gm./cm.^{3}

It is apparent that the small differences in density of the methyl methacrylate resins would have no significant effect on the weight of a denture in so far as the patient is concerned, whereas the pink rubber bases would be approximately 60 percent heavier in some cases. The typical upper denture of methyl methacrylate resin will weigh, say, 20 gm., one-half of which may be teeth, leaving 10 gm. of resin. If a duplicate denture was made using the densest base rubber given in Table IV, it would weigh about 6 gm. more than the methyl meth-



2—Cured resin test specimens: A, cake molded in plaster mold; B, transverse test specimen machined from a similar cake; C, specimen broken in test; D, specimen bent in test; E, specimen used for water sorption

acrylate resin denture. This would be quite noticeable to the patient.

Transverse tests. The strength of any material may be measured in several ways, each of which has its particular significance. Tensile, compression, torsion and impact tests are often used. Tensile and impact tests are the most generally specified for evaluating the strength of denture base material. These tests have been used because the profession's ideas on plastics have been largely influenced by studies of the properties of ceramic and metallic materials. In this connection it is well to recall that the fundamentally different nature and behavior of a resin, in comparison with those of a metal, make the testing of these materials quite a different problem. For instance, the time factor in the application of the load is of major importance in the testing of plastics, while it is not so critical in testing elastic materials such as steel.

The selection of the transverse test, designed for denture base materials, was influenced by the desire to make the test conditions approximate service conditions as nearly as practicable. As a denture is subjected primarily to bending stresses, a bending or transverse test more nearly represents service conditions than would either a tensile test or a compression test. The test was made at 37 deg. C. (99 deg. F.) by applying the load at the rate of 500 gm. per minute at the center of a 50-mm. span of a specimen and recording the deflection. Details of the tests are given in another publication.[8] The specimen's width (10 mm.) and thickness (2.5 mm.) are representative of sections of dentures and the span (50 mm.) is comparable to the posterior width of a denture.

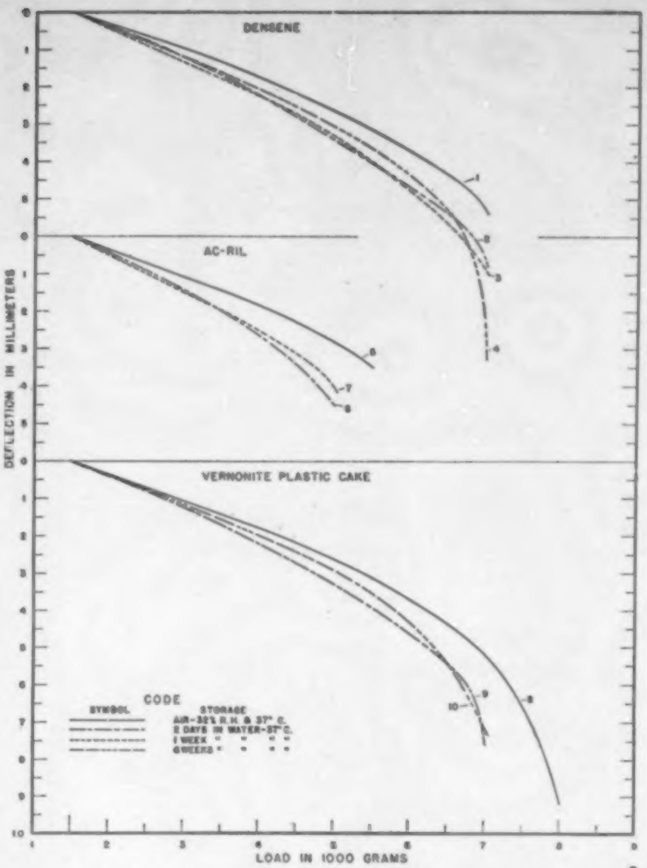
Useful information on the mechanical properties of denture resins is obtained from the load-deflection relationship as determined by this test. For example, a "tough" material will support a high load and also will have a large deflection; while a brittle material, even though it is strong, will deflect a relatively small amount before fracture. Therefore, by choosing the proper limits of load and deflection it is possible to define the desired mechanical properties.

In the specification, the deflection is limited at two loads (4000 and 6000 gm.). At the load of 4000 gm., the limit set for the deflection requires that the modulus of elasticity be relatively high—in other words, that the materials be stiff. The higher load (6000 gm.) insures that the material will have adequate strength. At this load a range of deflection is allowed. The minimum limit excludes brittle materials, while the maximum limit excludes materials with insufficient stiffness.

Table III—Change in Weight, Water Sorption and Dimensional Change of Denture Base Materials

1	2	3	4	5	6	7
Type	*Trade brand*	*Water sorption*[1] *at 25° C. (77° F.), mg./cm.*^{2}	*Change in weight ("solubility"),*[2] *percent*	*Dimensional change*[3] *(linear), percent*	*Curing shrinkage (linear), percent*	*Net change*[4] *(linear), percent*
Methyl methacrylate	Crystolex cake	0.55	+0.01	+0.9	0.40	+0.50
	Lucitone cake	0.55	−0.09	+0.8	0.30	+0.50
	Vernonite cake	0.55	−0.07	+1.1	0.45	+0.65
	Acralite powder-liquid	0.45	−0.04	+0.8	0.45	+0.35
	Crystolex powder-liquid	0.50	−0.08	..	0.25	..
	Crystolex powder-liquid; clear	0.55	+0.02	..	0.30	..
	Densene powder-liquid	0.50	−0.06	+0.7	0.35	+0.35
	Livetone powder-liquid	0.50	−0.03	+0.9	..	..
	Lucitone powder-liquid	0.55	−0.08	..	0.40	..
	Lucitone powder-liquid; clear	0.50	−0.04	..	0.35	..
	Vernonite powder-liquid	0.55	+0.03	..	0.45	..
	Vernonite powder-liquid; clear	0.60	−0.04	..	0.40	..
	Nu-Tek powder	..	..	..	0.25	..
	Plexiglas sheet	0.55	−0.06	..	..	..
	Lucite sheet	0.55	−0.05	..	..	..
Acrylic-styrene copolymer	AcRil powder-liquid	0.50	−0.09	+0.5	0.35	+0.15
Acrylic-vinyl copolymer	Exelon blank	0.15	−0.02	+0.3	0.20	+0.10
	Exelon powder-liquid	0.25	−0.03	+0.3	0.20	+0.10
	Luxene 44 cake	0.20	−0.03	+0.2	0.35	+0.15
	Luxene 44 cake (new)	..	..	..	0.25	..
Cellulose compounds	Cellanite No. 60 blank	2.15	−0.37	+1.0	..	..
	Crystalite powder	2.45	−1.36	+3.4	..	..
	Hecolite blank	1.50	−0.28	+1.4	..	..
	Parfait R blank	2.00	−0.33	..	..	..
	Parfait X blank	6.25	−0.49	−2.0	..	..
Rubber	Ash's dark elastic	0.05	+0.01	−0.1	0.20	−0.30
	Herakles	0.10	−0.07	−0.2	0.25	−0.45
	McCormick's 8A	0.15	−0.04	−0.3	0.05	−0.35
	S. S. White pink denture B	0.10	−0.04	−0.6	0.15	−0.75
	Ash's gum pink	0.05	−0.02	..	0.10	..
	Traun's light pink	0.30	..	..	..	..

[1] Specimen size—disks 50 ± 1 mm. in diameter and 3.2 ± 0.2 mm. thick.
[2] Change in weight of specimens after water sorption test.
[3] Change in dimension of dentures (tuberosity to tuberosity) after 2 six-week cycles of wetting and drying.
[4] Column 5 minus column 6.



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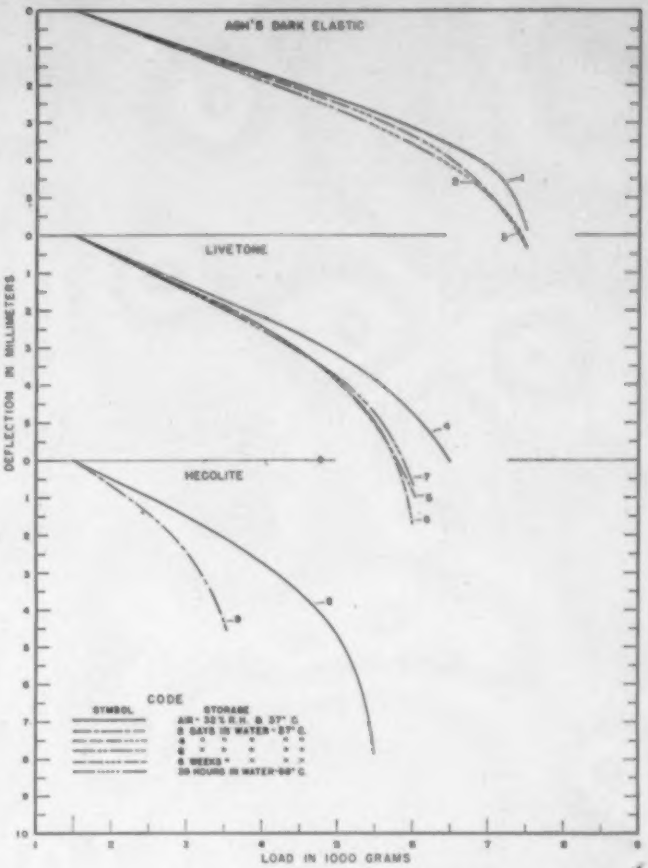

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3, 4, 5—*These three charts plot the report of transverse tests of denture base materials at 37 deg. C., showing the effect of storage in water on the resins*

5

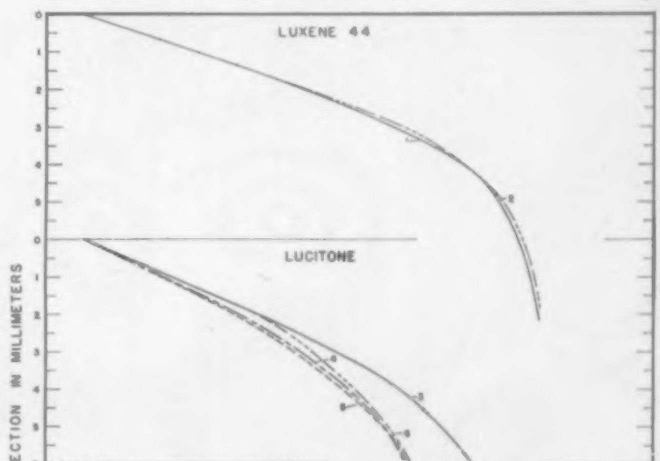


Table IV, columns 6–13, gives a summary of the results of the transverse tests on specimens subjected to a variety of treatments as indicated. A study of the values for minimum load (column 13) which was required to break the specimen or to force it through the supports indicates that the wet specimens are weaker than the dry ones, and that the effect of storage in water is more pronounced on the methyl methacrylate resins and cellulose compounds than on the acrylic-vinyl resins and rubber. Specimens of these resins stored in water show, in general, greater deflection for a given load than those stored in air. This is illustrated in Figs. 3, 4 and 5. Specimens stored in air at 32 percent relative humidity and 37 deg. C. (99 deg. F.), represented by the solid line in each case, show less deflection than do those stored in water at 37 deg. C. (99 deg. F.) for the various periods shown. A further study of these curves (Figs. 3, 4 and 5) will reveal that the deflections for specimens of the same material stored 2 days to 6 weeks in water at 37 deg. C. (99 deg. F.) were not significantly different. Acrylic-vinyl resins, represented by Luxene 44, and rubber, represented by Ash's dark elastic, are the least affected, as shown by curves 1 and 2, Fig. 5, and curves 1, 2 and 3, Fig. 4. The marked spread between the curves for air-stored and water-stored specimens of the cellulose nitrate material (Hecolite) indicates that it is greatly affected by storage in water (curves 8 and 9, Fig. 4). In general, the materials which take up the most water show the greatest increase in deflection under load when stored in water.

Inasmuch as a denture in service is constantly in contact with moisture, the transverse test selected for the specification requires that the specimens be stored in water at 37 deg. C. (99 deg. F.) for from 2 to 4 days prior to testing. The 2 to 4-day interval is permitted as the time of storage above 2 days is not critical, and the range simplifies the testing procedure by eliminating a rigid time schedule.

(*Please turn to next page for Table IV and then to page 104*)

TABLE IV.—MECHANICAL PROPERTIES OF DENTAL BASE MATERIALS

Trade brand	Color and form	Cure	Density (room temperature), gm./cm.[3]	Indentation[1] number (hardness), kg./mm.[2]	Deflection in mm. at 37° C. (99° F.) under transverse load, from 1500 gm. to: Storage of specimen[3] at 37° C. (99° F.)	2000 gm.	3000 gm.	4000 gm.	5000 gm.	6000 gm.	7000 gm.	Maximum load, gm.[3]
1	2	3	4	5	6	7	8	9	10	11	12	13
		DENTAL METHYL METHACRYLATE RESINS										
Acralite	Pink											
	Powder-liquid	As manufacturer recommends	1.175	20.0	32% relative humidity	0.36	1.04	1.86	2.78	3.81	5.91	7500
	Powder-liquid	As manufacturer recommends	...	...	2 days in water	0.40	1.30	2.24	3.40	5.08	...	6800
	Powder-liquid	As manufacturer recommends	...	...	6 weeks in water	0.44	1.32	2.26	3.37	...	...	5800
Crystolex	Pink, plastic cake	As manufacturer recommends	1.181	20.7	2 days in water	0.38	1.20	2.08	3.10	4.26	6.44	7900
	Powder-liquid	As manufacturer recommends	1.176	17.4	32% relative humidity	0.35	1.10	1.91	2.86	4.06	6.67	7500
	Powder-liquid	1/2 hr. 60–100° C. (140–212° F.), 1 hr. at 100° C. (212° F.)	...	...	2 days in water	0.48	1.44	2.48	4.27	7.94	...	6200
	Powder-liquid	1/2 hr. 50–100° C. (122–212° F.), 3 hr. at 100° C.	...	...	2 days in water	0.44	1.44	2.58	4.12	6.91	...	6500
	Powder-liquid	As manufacturer recommends	...	...	3.0% water[4]	0.40	1.17	1.99	3.56	...	...	5500
	Clear											
	Powder-liquid	100° C. for 1 hr.	...	16.4	2 days in water	0.47	1.48	2.63	4.36	...	...	6100
	Powder-liquid	1/2 hr. 50–100° C., 3 hr. at 100° C.	1.176	...	2 days in water	0.46	1.37	2.46	3.80	6.52	...	6500
Densene	Pink											
	Powder-liquid	As manufacturer recommends	1.172	21.5	32% relative humidity	0.34	.96	1.82	2.68	3.74	5.32	7800
	Powder-liquid	As manufacturer recommends	...	...	2 days in water	0.38	1.20	2.27	3.47	4.73	7.25	7500
	Powder-liquid	As manufacturer recommends	...	...	1 week in water	0.49	1.41	2.28	3.34	4.86	6.42	7500
	Powder-liquid	As manufacturer recommends	...	...	6 weeks in water	0.43	1.23	2.05	3.12	4.46	9.57	7200
Livetone	Pink											
	Powder-liquid	As manufacturer recommends	1.172	20.8	32% relative humidity	0.41	1.26	2.08	3.02	4.45	...	7200
	Powder-liquid	As manufacturer recommends	...	...	2 days in water	0.44	1.39	2.45	3.93	6.84	...	6500
	Powder-liquid	As manufacturer recommends	...	...	4 days in water	0.47	1.42	2.47	3.90	7.69	...	6500
	Powder-liquid	As manufacturer recommends	...	...	6 days in water[4]	0.48	1.46	2.54	3.77	6.63	...	6500
	Powder-liquid	As manufacturer recommends	...	...	2.20% water	0.38	1.19	2.17	...	...	...	5000
Lucitone	Pink, plastic-cake	As manufacturer recommends	1.180	20.8	2 days in water	0.39	1.22	2.14	3.28	4.57	7.17	7500
	Powder-liquid	As manufacturer recommends	1.171	21.5	32% relative humidity	0.38	1.14	1.94	2.84	3.99	6.02	7700
	Powder-liquid	As manufacturer recommends	...	...	4 days in water	0.42	1.30	2.20	3.21	4.55	8.56	7500
	Powder-liquid	As manufacturer recommends	...	...	6 days in water	0.41	1.24	2.11	3.24	4.73	8.86	7500
	Powder-liquid	5 days at 50° C. (122° F.)	...	...	2 days in water	0.48	1.53	2.74	4.32	7.37	...	6500
	Powder-liquid	10 days at 50° C.	...	...	32% relative humidity	0.40	1.24	2.15	3.22	4.61	8.92	7300
	Powder-liquid	23 days at 50° C.	...	...	2 days in water	0.44	1.39	2.49	3.84	6.30	...	6700
	Powder-liquid	45 minutes at 132° C. (270° F.)	...	...	2 days in water	0.44	1.34	2.34	3.57	5.42	...	7000
	Clear											
	Powder-liquid	As manufacturer recommends	1.172	20.6	2 days in water	0.38	1.20	2.14	3.22	4.63	...	6500
Nu-Tek	Powder-liquid	5 days at 50° C.	...	...	2 days in water	0.62	1.92	3.61	10.08	...	...	5100
Vernonite	Pink, powder	As manufacturer recommends	...	18.8	3 days in water	0.49	1.68	3.22	5.84	...	...	5500
	Pink, plastic-cake	As manufacturer recommends	1.182	21.0	32% relative humidity	0.35	1.07	1.78	2.64	3.71	5.14	8000
	Plastic-cake	As manufacturer recommends	...	...	2 days in water	0.38	1.24	2.19	3.28	4.62	7.38	7700
	Plastic-cake	As manufacturer recommends	...	...	6 weeks in water	0.38	1.14	2.00	2.88	4.25	7.10	7500
	Powder-liquid	As manufacturer recommends	1.170	18.6	2 days in water	0.46	1.47	2.60	4.06	6.09	...	6200
	Clear											
	Powder-liquid	As manufacturer recommends	1.160	18.1	2 days in water	0.48	1.50	2.66	4.18	7.09	...	6500

INDUSTRIAL METHYL METHACRYLATE RESINS												
Lucite	Clear, sheet	....	1.178	18.8	32% relative humidity	0.42	1.31	2.21	3.18	4.58	7.64	7500
	Sheet	....	...	...	2 days in water	0.46	1.42	2.52	3.99	7.25	...	6500
	Sheet	....	...	...	1 week in water	0.48	1.47	2.65	4.17	7.57	...	6500
	Sheet	....	...	...	6 weeks in water	0.45	1.30	2.20	3.88	8.10	...	6200
	Sheet	....	...	...	1.6% water[4]	0.37	1.11	2.00	3.19	4.84	...	7000
Plexiglas	Clear, sheet	....	1.181	17.2	32% relative humidity	0.38	1.12	1.91	2.81	4.05	9.07	7000
	Sheet	....	...	...	2 days in water	0.42	1.33	2.51	4.19	8.34	...	6200
ACRYLIC-STYRENE RESIN												
AcRil	Pink											
	Powder-liquid	As manufacturer recommends	1.157	19.2	32% relative humidity	0.38	1.11	1.85	2.84	3.56	...	6100
	Powder-liquid	As manufacturer recommends	...	...	2 days in water	0.44	1.48	2.67	4.55	...	...	5500
	Powder-liquid	As manufacturer recommends	...	...	1 week in water	0.49	1.49	2.48	4.08	...	...	5200
ACRYLIC-VINYL RESINS												
Exelon	Pink, blank	As manufacturer recommends	1.357	12.4	2 days in water	0.32	1.00	1.70	2.54	3.73	...	7000
	Powder-liquid	As manufacturer recommends	1.209	19.8	2 days in water	0.41	1.33	2.31	3.50	5.17	...	6200
Luxene 44	Pink, plastic-cake	As manufacturer recommends	1.316	14.4	32% relative humidity	0.33	1.00	1.70	2.52	3.43	5.12	8200
	Plastic-cake	As manufacturer recommends	...	...	6 weeks in water	0.34	1.00	1.71	2.42	3.30	4.90	7900
Luxene (new sample)	Plastic-cake	As manufacturer recommends	...	15.1	2 days in water	0.38	1.22	2.20	3.33	5.10	...	7000
CELLULOSE COMPOUNDS												
Cellanite No. 60[5]	Pink, blank	As manufacturer recommends	1.197	10.3	32% relative humidity	1.60	...	...	...	...	...	2600
	Blank	As manufacturer recommends	...	...	6 weeks in water	2.44	...	...	...	...	...	2500
Crystalite	Powder	As manufacturer recommends	1.304	10.3	2 days in water	...	...	...	...	...	...	1500
Hecolite	Blank	As manufacturer recommends	1.378	15.2	32% relative humidity	0.48	1.49	2.72	4.65	...	...	6000
	Blank	As manufacturer recommends	...	...	2 days in water	0.68	2.38	...	...	...	...	4000
Parfait R	Blank	As manufacturer recommends	1.198	11.9	2 days in water	0.60	2.04	4.92	...	...	...	4800
Parfait X	Blank	As manufacturer recommends	1.275	12.9	2 days in water	...	...	...	...	...	...	2000
RUBBERS												
Ash's dark elastic (base)	Olive											
	Plastic-sheet	As manufacturer recommends	1.251	13.4	6 weeks in water	0.36	1.05	1.75	2.47	3.40	4.89	8000
	Plastic-sheet	As manufacturer recommends	...	...	0.73% water[4]	0.37	1.12	1.88	2.64	3.56	4.90	8000
Ash gum pink (veneer)	Pink, plastic-sheet	As manufacturer recommends	2.428	15.5	2 days in water	0.23	0.72	1.39	2.61	...	...	6000
Herakles (base)	Olive											
	Plastic-sheet	As manufacturer recommends	1.249	13.7	3 days in water	0.38	1.14	1.91	2.79	3.70	5.10	7800
McCormick 8a (all-purpose)	Pink, plastic-sheet	As manufacturer recommends	1.660	19.3	2 days in water	0.65	2.93	...	...	...	...	4000
Traun's light pink (veneer)	Pink, plastic-sheet	As manufacturer recommends	2.666	17.0	2 days in water	0.26	0.78	1.40	2.08	2.86	4.19	7600
S. S. White pink denture B (all-purpose)	Pink, plastic-sheet	As manufacturer recommends	1.872	19.3	2 days in water	0.22	0.64	1.14	1.70	2.34	3.21	7800
1	2	3	4	5	6	7	8	9	10	11	12	13

[1] Indentation measured with Knoop indenter under a 50-gm. load with a 5-sec. contact at room temperature.
[2] Specimens were 2.5 mm. thick by 10 mm. wide by 65 mm. long and were loaded over a 50-mm. span at the rate of 500 gm. a minute. An initial load of 1500 gm. was applied and the zero reading taken. Deflections of individual specimens showed variations as great as 10 percent in some cases.
[3] Load at which specimens broke or were forced through supports.
[4] Increase in weight of specimens immersed in water at 98° C. (208° F.) for 38 hours before test.
[5] Advertised as a resinous material developed solely for dentures.

(*Please turn to page 104*)

Plastics for water meter disks

by JOHN D. PIPER*

THIS paper describes tests undertaken to permit the selection of commercially available plastics for making water meter disks that will function satisfactorily in hot water. The results are believed to be of general interest because they supply engineering data on the plastic deformation and on the weight and dimensional changes of certain plastics caused by heating them at 100 deg. C. for over 1500 hours in air and in water.

The ordinary hard rubber water meter disk, although satisfactory for cold water service, fails upon exposure to hot water for even a short time; this happens, for example, if hot water from a neglected water heater "backs up" into the meter. Graphite composition disks are more resistant to deformation but are insufficiently resistant for continuous use in hot water.

Source, composition and properties of samples

Samples for test were obtained by requesting numerous manufacturers or vendors to submit samples approximately 1/4 in. thick of any plastics which they thought might be suitable for making water meter disks that would withstand hot water. The following requirements were specified:

1. The plastic should retain its size and shape in water at 100 deg. C.; that is, it should neither soften nor absorb sufficient water to cause appreciable swelling.
2. It should resist corrosion itself and should not promote the corrosion of metals, such as iron, brass or bronze, with which it is used.
3. It should have wear resistance and tensile strength comparable to those of hard rubber.
4. It should be easily machinable or moldable.
5. It should have a specific gravity close to that of water, preferably not over 1.35.

These requirements were selected after consideration both of information compiled by L. G. Lenhardt, Department of Water Supply, Detroit, and of data obtained by subjecting specimens from hard rubber and graphite composition meter disks to preliminary tests similar to those that will be described. The results of these preliminary tests showed that hot water caused both plastic deformation and swelling of the disks.

In response to the inquiry, seven manufacturers sent a total of ten samples of sheet plastics ranging in thickness from 0.059 to 0.276 inch. Some of the samples sent were recognized by their manufacturers as not meeting all of the requirements, particularly that relating to specific gravity. The ten, together with samples of hard rubber and graphite composition obtained from currently used meter disks, were tested to determine whether each had, or approached, the properties listed under requirements 1, 4 and 5.

The outstanding properties that were claimed for each plastic by its manufacturer are tabulated in column 2 of Table I; the compositions that were revealed are given in column 3; and the respective specific gravities, which were determined by a procedure described in American Society for Testing Materials Method D71-27, are given in column 4. Seven of

* Research Department, Detroit Edison Company.

TABLE I.—SOURCE, COMPOSITION AND SPECIFIC GRAVITY OF THE MATERIALS INVESTIGATED

Sample No.[a]	*Properties as given by manufacturer*	*Composition according to manufacturer*	*Specific gravity*[b] *25/25 deg. C., A.S.T.M. D71-27*
1	Water resistant, high mechanical strength, low specific gravity	Phenolic resin	<u>1.306</u>
2	Water and heat resistant	Phenolic resin	1.764
3	Meets requirements 1, 2 and 3. Fair machinability	Phenol-formaldehyde resin with asbestos, wood-flour and graphite filler	1.871
4	Water resistant, high tensile strength and impact resistance	Pure resin; no cellulose[c]	<u>1.300</u>
5	Same as 4 except high softening point	Pure resin; no cellulose[c]	<u>1.206</u>
6	Meets requirements 2 through 5, possibly requirement 1	Not revealed[d]	<u>1.205</u>
7	Meets requirements	Unfilled phenol-formaldehyde resin	<u>1.267</u>
8	Designed especially for valves and water meter disks	Mica-filled phenol-formaldehyde resin	1.871
9	Meets requirements	Laminated phenolic resin	<u>1.290</u>
10	High softening thermoplastic	Halogen-containing, otherwise confidential	1.697
11	Comparison material from graphite composition disks	Graphite composition[e]	1.842
12	Comparison material from hard rubber disk	Hard rubber	<u>1.174</u>

[a] Identification of samples which proved to be most satisfactory for water meter disks:
No. 1—Resinox L-5333, Monsanto Chemical Co.
No. 2—Resinox L-5334, Monsanto Chemical Co.
No. 3—Textolite 1386, General Electric Co.
No. 9—Micarta 273, Westinghouse Electric & Manufacturing Co.

[b] Specific gravities underlined met the arbitrarily chosen requirement.

[c] Nature of resin not revealed. Resins of similar trade name made by the same manufacturer are listed in Ellis' "Chemistry of Synthetic Resins" as being urea-formaldehyde or urea-formaldehyde phenol-formaldehyde resin.

[d] Nature of resin not revealed. Resins of similar trade name made by the same manufacturer are listed in Ellis as being urea-formaldehyde or urea-formaldehyde aniline resin.

[e] Believed to contain a percentage of hard rubber.

the twelve samples, the specific gravities of which are underlined in the table, met the arbitrarily chosen specific gravity requirement. Even though the specific gravities of the remaining five were higher than the maximum thought to be desirable, these samples were not excluded from the subsequent tests because this group included two materials, designated as 8 and 11, that are currently used for water meter disks. Two of the samples having the higher specific gravity are included in the group of four plastics judged by the tests to have a superior combination of properties. These four samples are identified by their trade names in Table I.

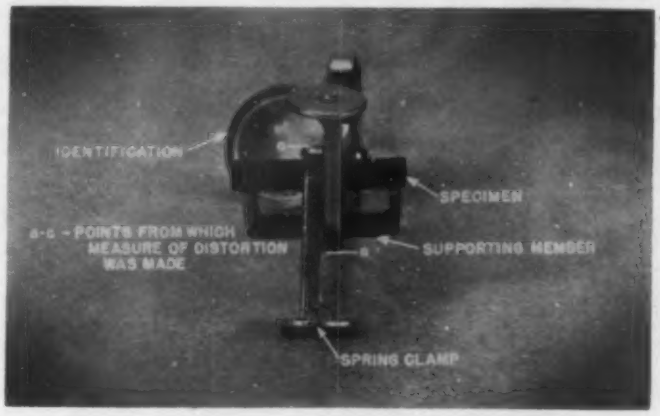
Plastic deformation at 100 deg. C. in air and in water

Tests were made to measure the relative resistances of the several plastics to plastic deformation. Specimens approximately $^1/_4$ in. wide by $1^1/_8$ in. long were machined from each of the samples. When the samples were requested, it was intended that the thicknesses of the specimens would be the thicknesses of the sheets from which they were cut. This was found to be impossible, however, because the samples received varied so greatly in thickness. Samples 1, 2, 3, 6, 7, 9, 11 and 12 were machined to approximately $^1/_8$ in. thick. Samples 8 and 10 were used in their original thicknesses, which were approximately $^1/_8$ inch. Samples 4 and 5 were so thin that it was necessary to place two specimens together to provide a total thickness of approximately $^1/_8$ in., and each of these pairs was used as a single specimen in order to obtain a measure of their resistance to plastic deformation, although it was recognized that a laminated structure would not necessarily give results that would be comparable with results obtained with solid specimens.

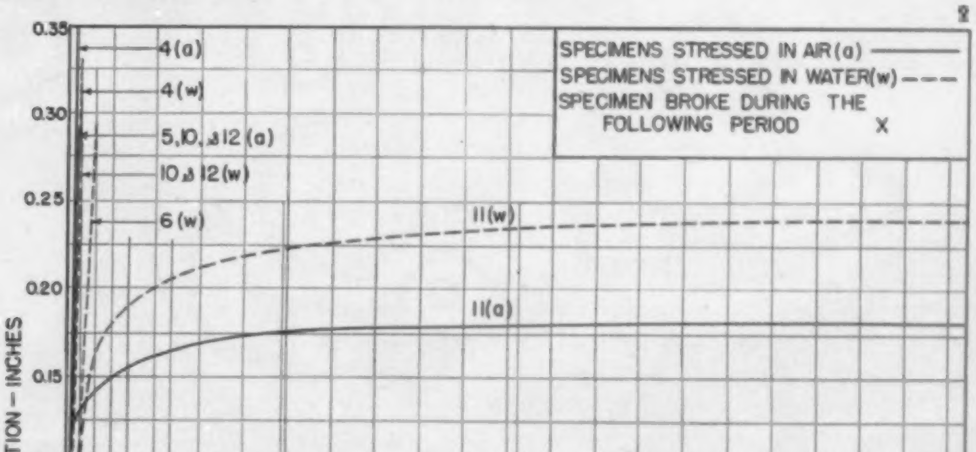
Each specimen was loaded as a simple beam by applying a load perpendicular to the broad face of the specimen at the middle of the span as is shown in Fig. 1. The supporting member was made of channel iron having a span of $^7/_8$ in. and a height of $^1/_4$ inch. The load was applied with a spring clamp such as is used to close rubber tubing. Each clamp was calibrated in ounces total load at the point of zero deflection of the specimen. Selection of the clamp used was determined by the thicknesses of the specimens, which ranged from 0.099 in. for the thinnest specimen of sample 10 to 0.146 in. for the thickest specimen of sample 8. The load averaged 81.5 oz. per $^1/_8$ in. of specimen thickness; the maximum was 85.1 oz. for the specimen of sample 1 that was heated in water, and the minimum was 78.1 oz. for the specimen of sample 1 that was heated in air. These loads produced an average fiber stress of approximately 1700 p.s.i. At room temperature only the specimens of samples 4, 5 and 10 underwent observable elastic deformation under these loads; and even in these cases the extent of elastic deformation was small as compared with the extent of plastic deformation caused by the heating to which the specimens were subsequently subjected.

One specimen of each sample, loaded as described, was immersed in water and heated in a sealed vessel at 100 deg. C. To differentiate between the effect of hot water and the effect of heat alone in the presence of air, another specimen of each sample, loaded in the same manner, was heated at the same temperature in air. The extent of distortion of the specimens at a given time was measured by the difference between the initial space separating the outside of the clamped jaws and the corresponding space at the given time. The points from which measurements were made are shown in Fig. 1.

The relative extents to which the specimens withstood being heated in air and in water at 100 deg. C. while loaded are summarized graphically in Fig. 2. After 20 hr., specimens of samples 4, 5, 10 and 12 (heated in air), and of samples 4, 10 and 12 (heated in water), were bent nearly to the base of the

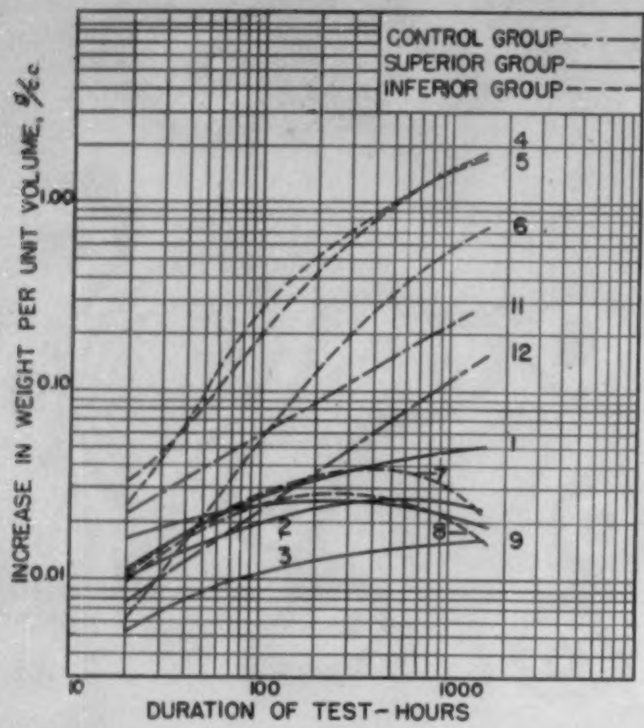


1



2

1—*Apparatus used for applying the load in the distortion test.* 2—*Plastic deformation at 100 deg. C. in air and water*



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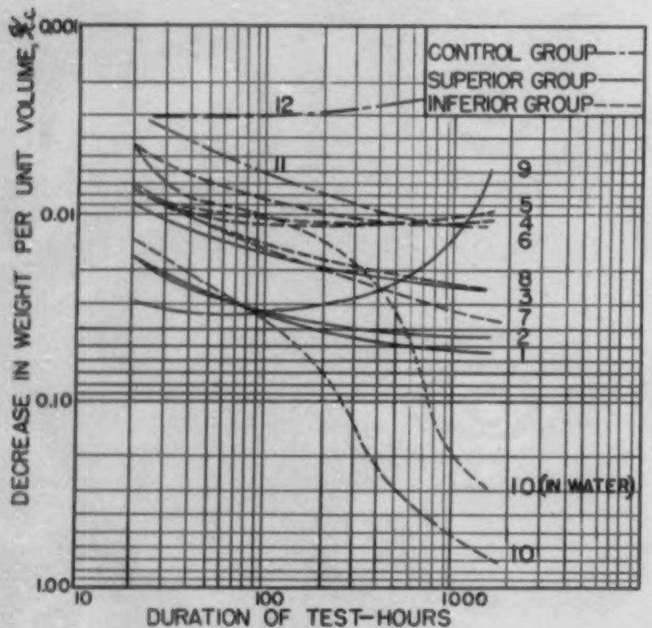

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3—*Increase in weight of specimens heated in water at 100 deg. C.* 4—*Decrease in weight of specimens heated in air at 100 deg. C. (Also decrease in weight of specimen 10 heated in water.)* 5—*Comparison between the appearance of the specimens that were heated in air and the corresponding specimens that were heated in water. Specimens at the left side of each pair were heated in air, specimens at the right side, in water.* 6—*Change in dimensions of phenol-formaldehyde and control specimens heated in water at 100 deg. C.*

supporting member. These specimens were then discarded. The specimen of sample 6 that was heated in water was appreciably bent, and the specimen of sample 5 that was heated in water was broken. Each specimen that broke was replaced by a new one. If the replacement specimen also broke, the sample was eliminated from the tests. After being heated for 40 hr., the specimen of sample 6 that was heated in water was resting on the base of the supporting member and was therefore discarded. The specimen of sample 8 that was heated in water broke during this period. The replacement for sample 5 also broke.

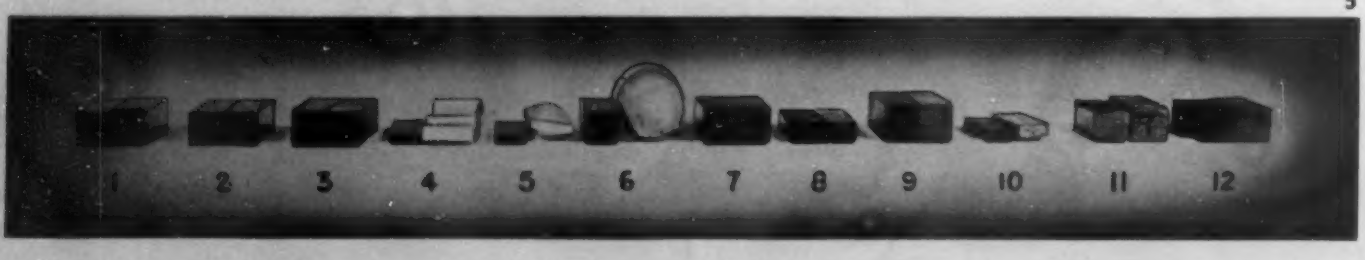
Only a few of the specimens retained on test beyond 40 hr. exhibited marked changes in appearance when inspected at the end of 104, 178, 364 and 770 hr. The replacement specimen for the mica-filled phenol-formaldehyde compound that had failed in water (sample 8) broke in the period between 40 and 104 hr. The specimen of the phenol-formaldehyde compound that was heated in air (sample 7) also broke in this period, and a replacement specimen of the same material broke in the period between 104 and 178 hr. The specimen of sample 6 that was heated in air broke in the period between 178 and 364 hr. This specimen was not replaced because the corresponding specimen that was heated in water had failed at the end of 40 hr. by plastic deformation. Both specimens of sample 11 underwent marked deformation during the first 40 hr. of the test but thereafter appeared to become harder and the rate of deformation became very low after 364 hr.

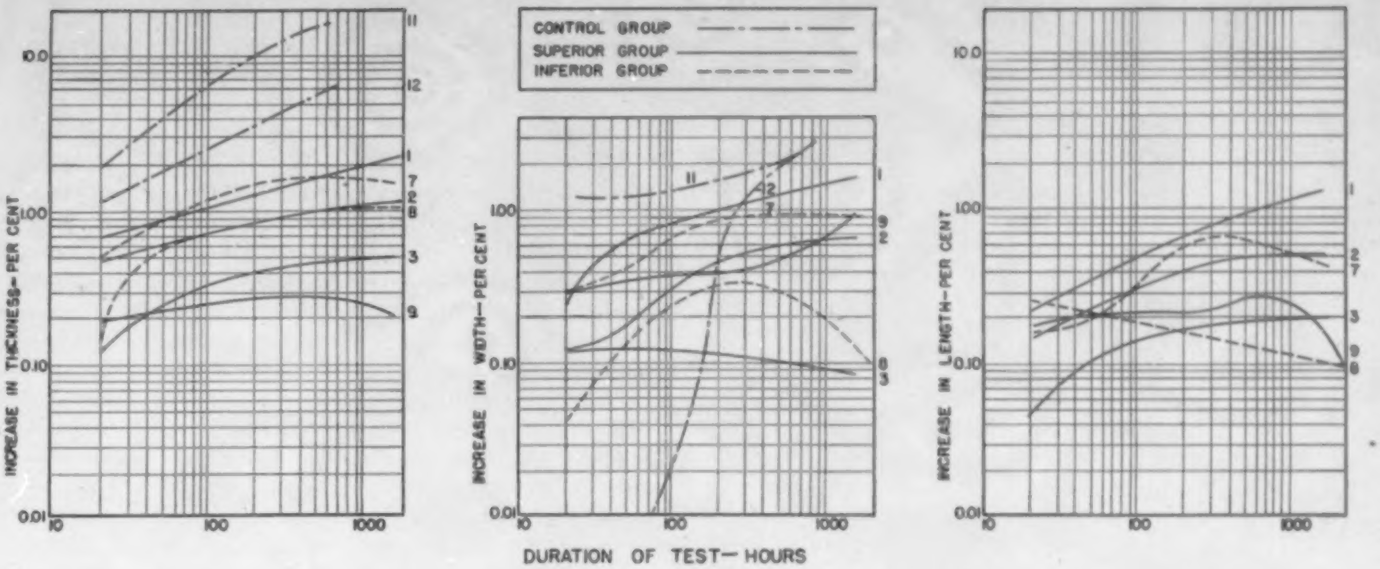
All of the specimens that showed superior resistance to deformation were of the phenol-formaldehyde type. For many of these the distortion was less than the error of measurement across the clamp. For this reason the permanent distortion was determined on the specimen itself at the conclusion of the 1535-hr. test. These measurements are recorded in Table II. Of the specimens heated in water, sample 3 was distorted the least, and was followed in order by samples 2, 9 and 1. The order of decreasing distortion for these four was also the order of decreasing specific gravity, except that the last two were interchanged. These four specimens were inspected visually

TABLE II.—DISTORTION OF PHENOL-FORMALDEHYDE SPECIMENS AFTER 1535 HR. AT 100 DEG. C.

Specimen	*Distortion in inches at the center of each $1^1/_8$-in. bar*
1 (dry)	0.0009
(wet)	0.0317
2 (dry)	0.0017
(wet)	0.0157
3 (dry)	0.0079
(wet)	0.0034
7 (dry)	Broke
(wet)	0.0441
8 (dry)	0.0021
(wet)	Broke
9 (dry)	0.0073
(wet)	0.0106

5





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for evidences of deterioration. Except for fine transverse cracks in the specimen of sample 1, opposite the point at which the load was applied, slight dulling of the luster was the only sign of deterioration. The corresponding specimens heated in air showed no signs of deterioration.

Changes in weight and dimensions

In addition to the tests made to show the extent to which the several plastics were deformed when loaded at 100 deg. C., tests were made to show the extent to which the weight and dimensions of the plastics changed when heated at 100 deg. C. in water and in air without being stressed. For this test two specimens, each the thickness of the samples, $^1/_4$ in. wide and 1 in. long, were machined from each sample and their weights and dimensions accurately determined. One specimen from each sample was heated in water at 100 deg. C. and the other in air at the same temperature. Testing of all specimens except those from samples 11 and 12 was carried out simultaneously with the distortion test previously described. Testing of specimens of samples 11 and 12 had been similarly conducted previously for a total time of 667 hours.

The progressive changes in weight of the specimens heated in water are shown in Fig. 3 and of those heated in air in Fig. 4. For convenience in comparing results of this test with the results of the distortion test, designations are used that divide the specimens into three groups, namely:

Superior group—those that supported their load better than did sample 11.

Control group—samples 11 and 12.

Inferior group—those that did not support their load so well as did sample 11.

Fig. 3 shows that the four plastics that had superior load-supporting properties also gained the least weight during immersion in water. Specimens 7 and 8, the other phenol-formaldehyde materials, also showed low gains in weight. After 300 hr. these two specimens lost weight, possibly indicating that something was being extracted from the specimens by the water. The same tendency was exhibited to a lesser extent by specimens 2 and 9.

Most of the specimens that were heated in air dried to nearly constant weight (Fig. 4). Following an initial decrease, specimen 9 increased in weight after the first 80 hr., possibly owing to slight oxidation of the fabric base. Specimens of sample 10 decreased markedly in weight not only when heated in air but also when heated in water, thus indicating decomposition. Decomposition was also indicated in the case of specimen 7, which instead of drying to constant weight continued to lose weight throughout the test. As was previously shown, this sample broke when heated under load in air.

The differences in dimensions of the specimens heated in air, as compared with those heated in water, are shown pictorially in Fig. 5, where the left-hand specimen of each pair is the one heated in air and the right-hand specimen the one heated in water. The greater dimensional stabilities of the phenolic samples 1, 2, 3, 7, 8 and 9 over those of the remaining samples, including comparison samples 11 and 12, which were subjected to heat for a much shorter period of time, are marked.

The numerical changes in dimensions of the control specimens and of all the phenol-formaldehyde specimens that were heated in water are shown in Fig. 6. All the corresponding specimens that were heated in air, except specimen 9, shrank gradually in each dimension. At the end of 1535 hr. these changes ranged between 0.2 and 1.3 percent. Specimen 9 increased slightly in both thickness and in width when heated in air. All of the phenol-formaldehyde compounds tested were considered to have sufficient dimensional stability for use in hot water.

Selection of the most suitable material

The tests have shown that some of the phenol-formaldehyde compounds on the market, including compounds having a low specific gravity, resist deformation caused by moisture absorption or by plastic flow, even at 100 deg. C. Therefore, they appear promising for use in water meter disks to be operated at elevated temperatures. No tests were made to determine the resistance of these compounds to wear or their effect on the corrosion of metal. Inasmuch as this type of compound has been used for water-lubricated bearings, however, it is believed that they will resist wear as water meter disk material and will not promote corrosion of the metal. Final evaluation of the relative merits of these or similar materials for water meter disks must be made by tests conducted on the disks themselves. This can be done only after fabricators have ascertained whether disks can be made to the tolerances required and at reasonable prices.

Naftolen—its use in plastics and coatings

by L. BORNSTEIN and F. ROSTLER*

It has always been an endeavor of the synthetic resin industry to find materials which can reduce the relatively high cost of plastics and, at the same time, to improve certain weaknesses of the products, such as, for instance, the alkali resistance. Recently, however, due to the defense program and to the increased use of plastics, raw materials have become so scarce that the need for extenders has become the foremost problem—a rather difficult one because a very limited number of materials can be added to plastics without considerably impairing their properties. Naftolen, an unsaturated hydrocarbon composition, therefore becomes especially interesting in the present emergency.—ED.

NAFTOLEN[1] is the trade name for a group of hydrocarbon materials which originate from unsaturated components of petroleum.[2] The source is acid sludge, one of the waste materials of petroleum refining. The unsaturated character of Naftolen opens a wide field of application. It found its first application in the rubber industry, where it is being used in this country and abroad.[3]

The chemical reactivity of these unsaturated hydrocarbons pointed to their usefulness in developing plastics.[4] However, many years of research in this field were necessary to produce a material adapted to use in plastics, and to develop analytical methods for controlling the quality so as to be able to predict the properties of the finished plastic products with certainty.

The results of this research led to the consideration of industrial applications. In this connection the authors are indebted to Dr. G. E. Landt and his associates in the Continental-Diamond Fibre Co. for having carried out many test runs which were of great value in the industrial evaluation of this hydrocarbon material for laminated plastics. Illustrated on page 73 are types of laminated products which are being produced with varnishes containing this hydrocarbon product. The purpose of this article is to offer a general report as to the applicability of this new material in the plastics industry.

Appearance and physical properties of Naftolen: These are said to be between those of a resin and those of an oil, combining properties of both. A very steep viscosity-temperature curve and brittleness at low temperatures are two of the resinous characteristics. All grades are liquid at 212 deg. F. The viscosity is from 800 to 6000 cp at 122 deg. F., and from 25 to 60 cp at 212 deg. F., dependent on the grade. It has a specific gravity of slightly over one, and is completely miscible with all common solvents except diluted alcohol and water.

The electrical properties of Naftolen R10 and Naftolen 550, determined at 70 deg. F., are as follows:

Dielectric constant at	10^6 cycles	2.57
" " "	60 "	4.77
Power factor	10^6 "	0.0148
" "	60 "	0.077
Loss factor	10^6 "	0.0381
" "	60 "	0.228
Breakdown voltage, kilovolts	60 "	48

The electrical properties of Naftolen RC are somewhat lower.

Naftolen is essentially a mixture of unsaturated hydrocarbons of the analytical composition 90 percent of carbon and 10 percent of hydrogen. This suggests the general formula $(C_3H_4)_n$ for the bulk of the material. The value of n depends on the molecular weight and varies with different grades from 8 to 25. These hydrocarbons are not aromatic hydrocarbons but are of the cyclo-aliphatic type. The single hydrocarbons have, as a rule, two double bonds in a molecule. The iodine number of the grades now produced is between 40 and 60. The material is neutral. Acid and saponification numbers are zero. All grades have a high boiling point and cannot be distilled without cracking except under high vacuum. The chemical properties of this hydrocarbon product are somewhat between those of saturated mineral oil and the highly unsaturated vegetable oils. Like mineral oil it is stable in storage, but combines like vegetable oil with resin ingredients and shows drying properties in the presence of a drier.

The most important physical and chemical properties which make this new hydrocarbon product of value in the resin and lacquer field are its high electrical and chemical resistance. Being mainly a hydrocarbon material, free of oxygen and other dipole producing elements, it shows excellent electrical properties. In contrast to vegetable oil, resins and synthetic esters, it is unsaponifiable and therefore highly stable toward chemical and atmospheric influence.

Grades of Naftolen

Not all of the hydrocarbons sold under this name are equally suitable for plastics. By careful selection and blending, three grades have been developed which are suitable for this field.

Naftolen R10 is the standard grade recommended for synthetic resins where highest electrical properties are important.

Naftolen RC is a modification of the above for use with phenol-formaldehyde type resins. Which of these two grades should be used in resins of this type depends on the phenol employed in making the resin.

Naftolen 550 is a grade especially recommended for use in connection with vegetable oils for air-drying coatings.

Thermosetting resins

An application of this hydrocarbon product for plastics was developed first in manufacture of thermosetting resins—phenol-formaldehyde type. It was found that no useful resin can be obtained by condensing the hydrocarbons either with formaldehyde or with a phenol alone. Both materials are necessary for the condensation with these hydrocarbons. For this purpose 25 to 50 parts of the Naftolen to 100 parts of the phenol has been found to be the most practical proportion. The incorporation of the hydrocarbons in these plastics does not require any special equipment, and the manufacturing process is not changed. The only necessary condition is that the hydrocarbons must be condensed together with the other raw materials from the very beginning of the process, and not added at a later stage to the finished product.

The most satisfactory procedure for the production of these resins is to dissolve the hydrocarbons in the phenol in the reaction kettle and then to add the necessary amount of formaldehyde. The amount of formaldehyde necessary is somewhat less than in the same resin without the hydrocarbons.

* Wilmington Chemical Corporation.

[1] The trade mark Naftolen is registered in the United States, Canada and most of the European countries. The product is made in the U. S. by the Wilmington Chemical Corp.

[2] U. S. Patents Nos. 2,185,951–2.

[3] India Rubber World, Aug. 1941, pp. 47–50; Feb. 1942, pp. 473–7.

[4] U. S. Patent No. 2,247,411.

For example, when 25 percent of Naftolen (figured on cresols) is incorporated, the amount of formaldehyde necessary is 15 percent less than for the same amount of cresol without the hydrocarbons. The most suitable catalyst for the condensation is an alkaline catalyst, preferably ammonia. As to the amount of catalyst, it has been found that an increase over the usual amount is often advisable. The condensation is brought about by heating under reflux for the period of time necessary for reaction at a temperature in the neighborhood of 212 deg. F. For resins to be used for laminating purposes the reflux time for the mix containing the hydrocarbons should be about 10 minutes longer than that ordinarily employed in making phenolic laminating resins. The water present, and the water formed by reaction, together with traces of unreacted material are distilled off under vacuum until a resin of the desired melting point is obtained. The resin is then either discharged from the kettle as such or dissolved to a varnish by a suitable solvent. With resins made with the hydrocarbons, the distillation especially near the end is less critical because the resin is much more liquid at this stage than the ordinary resin and the distillation can be carried much further without danger of "freezing" in the kettle.

Condensation products made with certain phenols sometimes have a turbid appearance after hardening, but cloudiness of the hardened resin does not affect the properties. However, if an actual separation of non-condensed components is obtained, as with carbolic acid, or where turbidity is disturbing, it is advisable to use a higher boiling cresol and/or to substitute Naftolen RC for Naftolen R10. As a general rule the compatibility of phenols with these hydrocarbons increases in the following order:

Phenol (carbolic acid)
Cresol with at least 40 percent meta-cresol content
Cresylic acid of low boiling range
Cresylic acid of high boiling range
Xylenols
Substituted phenols such as para-tertiary-amylphenol, and other phenols used in the manufacture of oil-soluble resins

The properties of the finished resin are decidedly improved by the incorporation of the hydrocarbons. For instance, in the application of resin containing the hydrocarbons for laminating varnishes, the finished laminated boards show excellent lamination (because of improved impregnation power), reduced water absorption and improved electrical

TABLE I—EFFECT OF NAFTOLEN R 10 ON THE PROPERTIES OF FINE FABRIC-BASE LAMINATED PLASTICS

	Naftolen-free resin	*Resin containing 25% of Naftolen*	*Naftolen-free resin*	*Resin containing 25% of Naftolen*
Thickness, in.	1/16	1/16	1/8	1/8
Specific gravity	1.35	1.36	1.35	1.32
Water absorption in 24 hr., %	4.8	1.2	3.15	1.32
Tensile strength, lb./sq. in.	15,220	15,210	13,450	15,800
Flexural strength, lb./sq. in.	19,880	20,180	26,300	28,750
Power factor	0.0526	0.0358	0.0620	0.0500
Dielectric constant	5.46	4.33	5.85	6.29
Dielectric loss factor	0.488	0.218	0.387	0.315
Dielectric strength, volts/Mil	410	730	400	490

PHOTO. COURTESY CONTINENTAL DIAMOND FIBRE CO.

Some laminated sheets, rods and tubes produced with resins containing this unsaturated hydrocarbon composition

properties and chemical resistance, especially against alkalies. Table I gives a comparison of the properties of laminated boards made with ordinary phenolic resins and with resins containing the hydrocarbons described.

The following data indicate the proportions of ingredients to be used, and the resulting yield of laminating varnish, in making a resin containing this material as compared with the ordinary resin.

	To make Naftolen-free varnish	*To make Naftolen-containing varnish*
	1000 lb.	1000 lb. of cresylic acid
and	...	250 lb. of Naftolen R10
are condensed with	900 lb.	750 lb. of formaldehyde (40%)
using as catalyst	60 lb.	70 lb. of ammonia (28%)
to yield	*1100* lb.	*1350* lb. of resin.
Reduction with	900 lb.	1000 lb. of alcohol
results in	*2000* lb.	*2350* lb. of laminating varnish.

This comparison is of interest from an economic aspect, especially under present conditions where cresol and formaldehyde are scarce. It shows that with the same amount of cresol and a smaller amount of formaldehyde, 250 additional pounds of resin or 350 additional pounds of laminating varnish are obtained. This means a saving of about 18.5 percent of the cresylic acid and 32 percent of the formaldehyde in the resin.

In laminating varnishes for punching stock of the type made with China wood oil, Naftolen can replace 50 to 70 percent of the China wood oil, the remaining amount of China wood oil serving mainly as a plasticizer, since complete replacement of China wood oil by the hydrocarbons tends to give a brittle sheet. This remainder, however, can in most cases be replaced by oiticica oil, certain grades of dehydrated castor oil and soya bean oil, or mixtures thereof.

Cresol-formaldehyde-Naftolen resins can be combined with lignin resins. Various combinations with Marathon lignin resins have been carried out with satisfactory results.

The material also finds application in resins for brush cements, impregnating varnishes for wood, abrasive cements and the like, either liquid or solid. The condensation reactions may be carried out with an alkaline or neutral catalyst.

In one stage molding powders, this hydrocarbon material can be used in two ways: as an original component of the resin, as described before, or as a lubricant incorporated directly into the molding powder. These resins have improved electrical and flowing properties.

In two stage molding powders, Naftolen should be incorporated directly into the molding powder, since it is not advisable to use it in condensation reactions with acid catalysts, such as are employed in making this type of molding powder.

Oleoresinous varnishes

Oleoresinous varnishes are another large field of application for Naftolen. In these varnishes the material can be applied in both components: In the resin component as a compounding material or modifying agent for the oil-soluble resin, and as a part of the oil component in the varnish. In the first instance, the hydrocarbons are applied in the same manner as in the resins for laminating. As mentioned before, the product is entirely compatible with the various substituted phenols used in the oil-soluble resin and also with natural resins such as wood rosin, copal, kauri, etc., which are applied as modifying agents. Being unsaponifiable, the hydrocarbons improve the alkali resistance of modified resins.

The product is also applied as a modifying agent for alkyd resins alone or together with fatty acids, particularly in cases where the color of the resin is of minor importance.

The iodine number mentioned in the foregoing description of the properties indicates that the hydrocarbon material has certain drying characteristics. However, it cannot be termed an air-drying oil, as Naftolen by itself does not show any perceptible drying in air. Its characteristic advantages are most in evidence in compounds containing both a drying oil and resin, and in varnishes it fills the gap between these two components. The hydrocarbons fortify the generally

Improved resistance of laminating varnishes fortified with this hydrocarbon composition is shown in this panel, which was exposed to the weather for 6 months. The sections were coated as follows: **1**—*Linseed oil : Naftolen 550 : 100 percent phenolic resin—1.5 : 0.5 : 1.* **2**—*Linseed oil : Naftolen 550 : 100 percent phenolic resin—1 : 1 : 1.* **3**—*Linseed oil : 100 percent phenolic resin—2 : 1*

poor alkali resistance of varnishes. Pictured above is a panel which has been exposed to natural weather effects for six months, and illustrates the improved resistance of a Naftolen-containing varnish.

Contrary to the resin process where the hydrocarbons are added together with the other ingredients before condensation, in the production of oleoresinous varnishes the hydrocarbons are preferably added late in the process after the bodying of the drying oils and resin. Highly reactive resin types are the best to be used for these varnishes. In these types of varnishes the product shows a very good anti-skinning effect. As little as 2.5 per cent of the hydrocarbons on the total varnish reduces the skin formation considerably. A tung-linseed phenolic-resin varnish with 15 percent of the hydrocarbons does not show any skin formation after 100 hours. For best drying effect of varnishes containing the hydrocarbons, energetic driers, especially of the cobalt or manganese type, are recommended. *(Please turn to page 122)*

Plastics digest

This digest includes each month the more important articles of interest to those who make or use plastics. Mail request for periodicals mentioned directly to individual publishers

General

ECLIPSE OF TIN AND ALUMINUM. Plastics *5*, 248 (Jan. 1942). An almost completely non-metallic collapsible tube was recently put on the market in England by Herts Pharmaceuticals, Ltd. It uses three moldings: one, the cap in black plastic; two, the black mushroom collar; and three, the white, threaded nozzle which continues as a mushroom shape within. The black mushroom is screwed tightly over the white mushroom, holding firmly between them the tubular body. The latter consists of a plastic sheet lining, strongly protected on the outside by a fabric cover, probably artificial silk. The only metal part is the sealing strip at the bottom end.

CURRENT USE AND CONSERVATION OF PHENOL - FORMALDEHYDE PLASTICS IN AUTOMOBILE VEHICLES. SAE Journal *50*, 32, 68 (Feb. 1942). Although this effort to conserve phenol-formaldehyde resin in automobile production recently reached the 100 percent mark because of a directive from another source, this report of the Plastics Subcommittee of the SAE War Engineering Board is of interest because of its review of applications of phenolic resins in automotive parts. These are tabulated as ignition system parts, such as distributor heads, coil parts and switches, brake linings, clutch facings, timing gears, insulation on windings of generator and starter motors, oil seals, sheet insulators in electrical equipment and certain coatings. It is rather startling to find the Subcommittee recommending rubber and secondary aluminum as substitutes for phenol-formaldehyde plastics. Total use of phenol-formaldehyde resin in cars after replacement with the above materials and amount of replaced resin are given in pounds as follows: Car A, .78 and .001; Car B, 1.099 and .831; Car C, 1.733 and no figure cited for replacement.

INFORMATION ON FLEXIBLE TRANSPARENT AND TRANSLUCENT SUBSTITUTES FOR WINDOW GLASS. R. J. Moore and H. W. MacKinney. Trans. Am. Inst. Chem. Engineers *38*, 237–44 (Feb. 25, 1942). The suitability and availability of materials to replace window glass in case of air raid damage are considered. It is concluded that the best readily available material consists of a clear plastic film, such as cellulose acetate, ethylcellulose or a vinyl copolymer, supported by an open textile mesh (net or "marquisette"). It is estimated that approximately 50,000,000 sq. yd. of such a material would be needed to replace glass in an air raid protection program covering the areas within 500 miles of the Atlantic and Pacific coasts.

UREA TREATMENT OF LUMBER. J. F. T. Berliner. Mechanical Engineering *64*, 181–6 (Mar. 1942). The application of urea to wood to prevent checking is reviewed. The Forest Products Laboratory's work on making wood thermoplastic at about 210 deg. F. by impregnation with urea is also discussed. The amount of urea required is approximately 15 to 25 percent of the dry weight of the wood. Urea-impregnated wood shavings, chips or sawdust can also be molded at elevated temperatures and pressures.

SYNTHETIC RESINS AND PLASTICS. H. A. Neville. J. Chemical Education *19*, 9–14 (Jan. 1942). A general review of plastics and their applications with flow charts reproduced from the Plastics Catalog showing various manufacturing steps. Molding and casting, coatings and plastic films for laminated glass are among the topics considered.

Materials and Manufacture

DESIGN OF A UREA-RESIN PLANT. A. Brothman and A. P. Weber. Chem. and Met. Eng. *48*, 73–5, 82 (Dec. 1941). Data on the design of a plant for the manufacture of urea resin for use as a plywood adhesive are given. Nickel and nickel-clad steel are specified for the equipment, which consists of three main parts: resin kettle, refluxing condenser and dehydrating apparatus. The design of the horseshoe-type stirrer, stuffing box and bottom guide in the resin kettle are given particular attention. The heat of reaction of urea resin is given as 100 Btu. per hour per pound of reaction mass.

PREPARATION OF PLASTICS AND ELASTOMERS IN LIQUID AMMONIA. R. G. Roberts. ACS Chem. and Eng. News *20*, 316 (Mar. 10, 1942). The products formed by the addition of proteins, such as casein and gluten, elastomeric substances, such as rubber latex and Thiokol, and combinations of these two types of materials to liquid ammonia are described. When powdered casein or gluten, either alone or mixed with other substances such as powdered egg shells, magnesium powder or iron oxides is quickly stirred into rubber latex, a dough is formed. When this is dropped into liquid ammonia, the latex coagulates, the dough swells to twice its original size and a vigorous exothermic reaction takes place. As the ammonia boils away, the dough shrinks to less than its original size, leaving a hard, tough, resilient plastic.

METAL COATINGS ON NON-CONDUCTING MATERIALS. Samuel Wein. Metal Finishing *39*, 666–72 (Dec. 1941); *40*, 24–5 (Jan. 1942). This is an extensive review of the literature on methods of applying metal coatings on non-conducting materials. The procedure is outlined in five steps: roughening the surface of the non-conductor, cleaning the surface, application of a conducting priming film, deposition of a thin film of copper, and plating silver, gold, chromium or other metal as a finishing coat on top of the thin copper film. Cleaning and silvering methods are discussed at length and complete details for silvering methyl methacrylate resin are given. Methods proposed for chemical deposition of films of copper and other metals are reviewed. Uses of metal coatings on non-conductors are listed; these include containers, mirrors, molds, museum objects, radio parts, transportation accessories, electrical items, industrial machine parts and novelties.

Molding

BASIC DO'S AND DON'TS IN APPLYING PLASTIC MOLDINGS. W. B. Hoey. Machine Design *14*, 47–51 (Jan. 1942). The author stresses the importance of understanding molding technique as well as the characteristics of the materials themselves. Many examples of molded items which did not give satisfactory performance in service and had to be modified are cited and the fundamental causes of the failures are pointed out. Several soundly engineered applications of plastics whose good design characteristics have been proved through years of use are also discussed.

Applications

WOOD - PLASTIC AIRPLANE PARTS. Curtis L. Bates. Aviation *1942*, 82–3, 182 (Jan.). Some resin-bonded plywood parts now used on aircaft are as follows: Tabs for trainers, pursuit and bomber planes; control surfaces on trainers and pursuits; navigator's table; floors for trainers and transports; bomb doors; landing gear doors; side panels; baggage doors; and fairing panels of various types. It is estimated that 10,000,000 pounds of aluminum could be saved by substituting wood-plastic parts on present Government contracts.

A NEW MODERN PLASTICS FEATURE

Technical briefs

Abstracts of articles on plastics in the world's scientific and engineering literature relating to properties and testing methods, or indicating significant trends and developments

Engineering

PLASTICS AS INDUSTRIAL MATERIAL. G. C. Gress. Refrigerating Eng. *43*, 7–11, 44, 58, 60 (Jan. 1942). This survey of plastics from the viewpoint of the refrigerating engineer concludes that polystyrene is especially suitable for such equipment. Factors governing selection of materials for this purpose are dielectric and mechanical strengths, chemical resistance, color and decorative qualities, corrosion resistance, heat conductivity and cost. Thermal conductivities of various materials in cal./sec./cm./deg. C. $\times 10^{-4}$ are listed as follows: polystyrene 2, phenol-formaldehyde moldings 5, urea-formaldehyde moldings 7, laminated phenolics 5, cast phenolics 4, cellulose plastics 5, expanded rubber .8, cork board .98, hair felt 1.05 and wool felt 1.40.

THE CONSERVATION OF RUBBER LATEX. R. O. Babbit. India Rubber World *105*, 370 (Jan. 1942). Paracoumarone-indene resin is suggested as an extender for rubber latex. Compositions made from equal parts of resin and rubber have good elasticity and flexibility. The modulus is reduced by increasing amounts of resin which makes it possible to use this material in conjunction with clay, whiting or other materials which have a tendency to increase the modulus.

THE DEVELOPMENT OF A PRESERVATIVE FOR GILL NETS. G. Cave-Browne-Cave and R. H. Clark. Can. J. Research *19*, *B*, 241–60 (1941). Service and laboratory tests on gill nets for use in sea water show that twine treated with a chlorinated rubber composition containing dibutyl phthalate and a bactericide results in prolonged life of the fibers.

RESIN PLASTICS. H. K. Sen. J. Indian Chem. Soc. *18*, 47–70 (1941). Shellac combined with 4–6 percent formaldehyde to give a product with a lower softening point and better heat stability than shellac. This modified shellac reacted with urea to produce a material which could be injection molded, although with a tendency to be thermosetting. The best impact strength and heat stability were obtained with 15 percent urea. Melamine reacted with the modified shellac to give a more brittle product. The resin formed from the modified shellac and phenol had better properties than a mixture of shellac and phenol-formaldehyde resin. Shellac treated with formaldehyde and guanidine yielded a product suitable for injection molding. Shellac and cashew-shell liquid gave elastic and resistant films.

Chemistry

SOME THEMES IN THE CHEMISTRY OF MACROMOLECULES. H. W. Melville. J. Chem. Soc. *1941*, 414–26 (July). The mechanism of the polymerization of vinyl compounds is reviewed. Interpolymerization, and the determination of the molecular weight and structure of vinyl polymers are considered. Both linear and three-dimensional macromolecules formed by the reaction of unsaturated organic compounds are discussed.

THE HARDENING PROCESS WITH PHENOL-FORMALDEHYDE RESINS. F. Hanus. J. Prakt. Chem. *158*, 245–53 (1941). 4,6 - di(hydroxymethyl) - 1 - hydroxy - 2 - cyclohexylbenzene, 4, 6 - dialdehydo - 1 - hydroxy - 2 - cyclohexylbenzene and 4,6-di(hydroxymethyl)-1-hydroxy-2-methoxybenzene were prepared and the amounts of water and formaldehyde evolved on curing by heat determined. An ether bridge structure between methylene groups of different molecules is probably formed first. The influence of substituents in the *p*-position is of greater significance in the curing process than of those in the *o*-position. *O*- and *p*-substituted compounds show only small differences on heating. Water and formaldehyde are evolved and dialdehydes are formed.

Properties

PHENOLIC RESINS. II. MECHANICAL PROPERTIES IN RELATION TO STRUCTURE. H. Stager, W. Siegfried and R. Sanger. Schweiz. Arch. angew. Wiss. Tech. 7, 153–74 (1941). Phenolic resins were made with various amounts of alkali and plates cured under various conditions. Photomicrographs show that these materials are heterogeneous, like metals, and that grains of one state of polymerization are surrounded by material of lower states of polymerization which is mechanically weaker.

Static and impact bending tests at different places on the plates bear this out. A plastometer for following the curing of the resins is described.

PHENOLIC RESINS. III. DIELECTRIC PROPERTIES. H. Stager, W. Siegfried and R. Sanger. Schweiz. Arch. angew. Wiss. Tech. 7, 201–8 (1941). The variation of the dielectric constant of several phenolic resins at 20 deg. and 90 deg. with frequency is shown in graphical form. Washing out the electrolyte ions in the manufacturing process results in a decrease in the loss factor which is more marked at low frequencies than at high frequencies. This is caused by mobile hydroxyl groups. It is necessary to decrease the mobility of the hydroxyl groups or to replace them with less mobile groups to reduce the dielectric loss at high frequencies.

PAPER DIELECTRICS CONTAINING CHLORINATED IMPREGNANTS. DETERIORATION IN D. C. FIELDS. D. A. McLean, L. Egerton, G. T. Kohman and M. Brotherton. Ind. Eng. Chem., *34*, 101–9 (Jan. 1942). The insulating papers studied were rag stock linen and kraft impregnated with chlorinated diphenyl (Aroclor 1254) and chlorinated naphthalene (Halowax 1001). The exchange capacity of insulating paper appears to be a property related to the actual dielectric performance. The indications are that large improvements can be effected by adding stabilizers to the impregnants. The nature of the stabilizer used is not revealed.

Testing

FIBER IDENTIFICATION. Textile Colorist *64*, 60–1 (Feb. 1942). Methods are suggested for the identification of various types of synthetic fibers, including nylon, Vinyon, casein, soybean, glass, cellulose acetate and viscous types. These supplement the identification procedures published in the "1941 Supplement to the Book of A. S. T. M. Standards, Part III," and in the "1941 Year Book of the American Association of Textile Chemists and Colorists."

RESINS AS MICROSCOPICAL MOUNTANTS. Plastics *6*, 7–8 (Feb. 1942). A suitable mounting medium for histological specimens is composed of 10 g. of polystyrene, 5 cc. of dibutyl phthalate and 35 cc. of xylol. Such preparations show no degradation after 14 months, if contamination with paraffin wax is avoided. The colors of bacteriological preparations are preserved much better in this medium than in Canada balsam.

Specifications

DENTURE BASE MATERIAL, ACRYLIC RESIN OR MIXTURES OF ACRYLIC AND OTHER RESINS. J. Am. Dental Assoc. *29*, 127–30 (Jan. 1942). This specification, based on the investigation reported in ACRYLIC RESINS FOR DENTURES (see p. 61 in this issue), includes packing, transverse deflection, water sorption, solubility and color stability tests.

Offset Printing Department
Letter Press Printing Department
ssembly Department—Hand Operations
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Die and Tool Department
Spraying Department
Modeling Department
Inspection Department
Extrusion Molding Department
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Conveyor Assembly Lines
Assembly Department—Machine Operatio
Polishing Department
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U.S. Plastics Patents

Copies of these patents are available from the U. S. Patent Office, Washington, D. C., at 10 cents each

RESIN EMULSION. H. C. Cheetham (to Resinous Products and Chemical Co.). U. S. 2,272,057, Feb. 3. A coating composition comprising a drying oil modified alkyd resin and a rosin-maleic acid resin emulsified in water.

PHOTOFLASH LAMP. M. J. Neumann de Margitta (assigned to Westinghouse Elec. & Mfg. Co.). U. S. 2,272,059, Feb. 3. A lamp comprising a light-passing self-supporting sealed container from the group of organic plastics characterized by translucency and flexibility.

EMULSION LACQUER. M. C. Moore (to Hercules Powder Co.). U. S. 2,272,152, Feb. 3. A smooth-drying emulsion finish which does not break readily in freezing weather contains nitrocellulose, a water-immiscible solvent and an aqueous solution of a nitrocellulose solvent.

PHENOLIC RESINS. R. Müller (to Bakelite Corp.). U. S. 2,272,154–5, Feb. 3. Effecting a phenol-formaldehyde resin condensation in presence of metallic magnesium; and condensing phenol with formaldehyde in presence of alkaline reagents after treatment of the phenol with a magnesium salt.

COLOR PHOTOGRAPHY. S. S. Fierke (to Eastman Kodak Co.). U. S. 2,272,191, Feb. 10. The support of a film for color photography is faced first with a vinyl acetal, vinyl acetate, reduced coumarone-indene or polystyrene resin colored and compounded with a red-sensitive emulsion and a cyan coupler; this is followed with layers of a like resin containing first a green-sensitive emulsion and a magenta coupler, then a blue-sensitive emulsion and a yellow coupler.

RECLAIMING PLASTICIZERS. W. E. Fisher and A. G. Bright (to Eastman Kodak Co.). U. S. 2,272,193, Feb. 10. Leaching out high-boiling plasticizers from film scrap with a water-miscible solvent which does not dissolve the film base, and distilling off the solvent to recover the plasticizer.

DIE CASTING. Louis H. Morin and Davis Marinsky. U. S. 2,272,220, Feb. 10. A machine for die casting thermoplastics has a cylinder, heated at the discharge end, from which the charge is forced into movable dies.

POLYSULPHIDE PLASTICS. W. Frost, G. Källner and O. Kölbl (to Silesia Verein Chemischer Fabriken). U. S. 2,272,-265, Feb. 10. Increasing the sulphur content of a polysulphide plastic by heating the plastic in an emulsified state in an aqueous dispersion of sulphur.

CASEIN PLASTICS. K. Ripper (to American Cyanamid Co.). U. S. 2,272,352, Feb. 10. Swelling casein in an aqueous solution of urea or thiourea and reacting the product with formaldehyde in faintly acid medium.

MOLDING CARTRIDGE. G. W. Wacker (to Grotelite Co.). U. S. 2,272,449, Feb. 10. A cartridge of thermosetting molding composition for injection molding has one end frangible under pressure while the other end of the cartridge forms a plunger to force the material through the ruptured end.

NITROGENOUS POLYMERS. H. Ulrich (to General Aniline and Film Corp.). U. S. 2,272,489, Feb. 10. Polymerizing an ethylene-imine derivative with a long chain alkyl halide such as hexadecyl chloride.

CELLULOSE ESTER FOILS. Alfred Fischl. U. S. 2,272,-662, Feb. 10. Applying successive layers of a dilute cellulose ester solution to a smooth support as droplets which coalesce to a smooth film, rolling the film and finally stripping it from the support.

PRINTING POWDER. A. De Vere Harnett. U. S. 2,272,-706, Feb. 10. A powder for use in raised printing is composed of ethylcellulose, a compatible resin, methyl abietate, calcium carbonate and coloring matter.

MOLDING COMPOSITION. E. F. Fiedler (to General Electric Co.). U. S. 2,272,742, Feb. 10. A thermosetting molding composition contains acid-hydrolyzed wood and at least 10 percent of a thermosetting phenolic resin, together with aniline.

OPTICAL RESIN. C. E. Barnes (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,272,827, Feb. 10. Forming transparent homogeneous resins by polymerizing an unsaturated compounded of the acrylate type, containing triphenylbenzene in solution.

ACETAL RESINS. H. Berg (to Dr. Alexander Wacker Ges. für Elektrochem. Ind. G. m. b. H.). U. S. 2,272,828, Feb. 10. Condensing polyvinyl alcohol with an aldehyde or ketone in sufficient water to form a crumbly mass in a kneading machine, and precipitating the resin as a powder by adding more water.

MOLDING. M. L. Macht (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,272,847, Feb. 10. As an external mold lubricant for use in molding organic plastics, a long chain dialkyl phosphate.

GRINDING WHEELS. S. S. Kistler (to Norton Co.). U. S. 2,272,873–4–5–6–7–8, Feb. 10. Bonding abrasive grains with amine-formaldehyde or amine-furfural resins which are heated at curing temperatures with polyvinyl chloride, rubber hydrochloride, chlorinated rubber, chlorinated isobutene resin or polyvinylidene dichloride; or with a polyhalogenated aliphatic hydrocarbon; or with a halohydrin; or with an arylenediamine dihydrohalide; or with a melamine hydrohalide; or with chlorinated or brominated fatty acids or fatty acid esters.

THERMOPLASTIC. F. L. Kilbourne, Jr. (to Firestone Tire and Rubber Co.). U. S. 2,272,888, Feb. 10. Making a resin by reaction of rubber with an acyl halide.

PLASTICIZED POLYSTYRENE. A. J. Warner and A. A. New (to International Standard Electric Corp.). U. S. 2,272,-996, Feb. 10. Plasticizing polystyrene resins with 4 to 20 percent of phenanthrene.

ACETAL RESINS. J. B. Hale (to Eastman Kodak Co.). U. S. 2,273,035, Feb. 17. Stabilizing polyvinyl acetal resins by effecting the reaction between an aldehyde and a hydrolyzed vinyl ester in presence of 2–6 percent of a polyhydric phenol.

PULP MOLDING DIE. G. J. Manson (to Keyes Fibre Co.). U. S. 2,273,055, Feb. 17. A die for molding pulp articles has superimposed horizontal mold sections with grooved working faces. *(Please turn to page 82)*

TECH-ART

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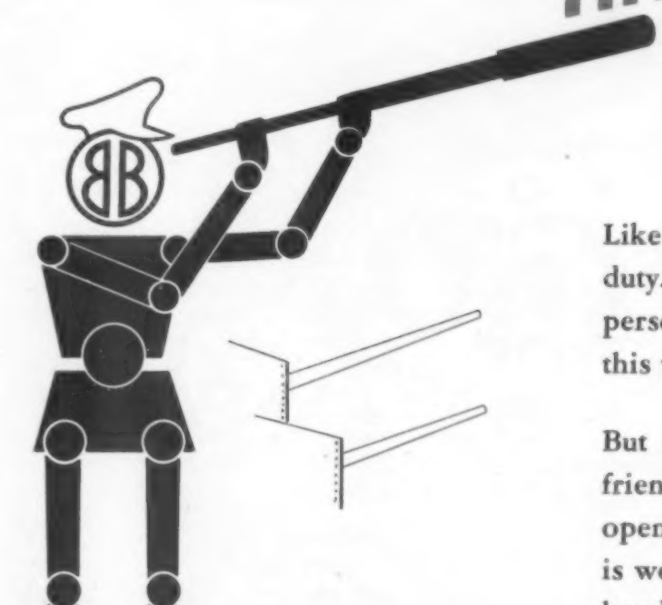

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HOSIERY. E. W. Rugeley and T. A. Feild, Jr. (to Carbide and Carbon Chemicals Corp.). U. S. 2,273,071, Feb. 17. Knitting stockings from yarn made of a vinyl chloride:vinyl acetate interpolymer.

WAX MODIFIER. A. H. Gleason (to Standard Oil Development Co.). U. S. 2,273,100, Feb. 17. Improving lubricants by adding an oil-soluble polymer formed by Friedel-Crafts condensation of an unsaturated or chlorinated alcohol and a phenol or arylamine.

MELT SPINNING. W. W. Heckert (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,273,105-6, Feb. 17. Spinning filaments from a melt supplied to spinnerets through a chamber traversed by a cooling medium; and improving uniformity of filament diameter by means of apparatus which controls spinning speeds of filaments emerging from the spinning nozzle.

MOLDING POWDER. A. Renfrew (to Imperial Chemical Industries, Ltd.). U. S. 2,273,140, Feb. 17. Dissolving a polyvinyl formal resin in acetic acid and atomizing the solution into aqueous ammonia.

MELT SPINNING. G. D. Graves (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,273,188, Feb. 17. Apparatus for melt spinning of linear superpolymers is attached directly to the reaction vessel in which the polymer is formed in molten condition.

DOORKNOBS. G. Harrison (to Doehler Die-Casting Co.). U. S. 2,273,190, Feb. 17. Making hollow molded knobs with projecting shanks by shaping the material in a simple two-part mold.

NYLON TIRE CORD. G. P. Hoff (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,273,200, Feb. 17. Low twist tire cord with stretchable filaments is made of oriented linear polyamide filaments.

VINYLIDENE CHLORIDE RESINS. A. W. Hanson and W. C. Goggin (to Dow Chemical Co.). U. S. 2,273,262, Feb. 17. Stabilizing vinylidene chloride polymers by adding an ester of aconitic acid.

BOARD BINDER. Albert L. Clapp. U. S. 2,272,313, Feb. 17. Forming a plastic froth of fiber, soap solution and a dispersed binder; and making sheets, boards and molded shapes therefrom.

RUBBER HYDROCHLORIDE THREAD. G. D. Mallory (to Wingfoot Corp.). U. S. 2,273,364, Feb. 17. Coating part or all of a rubber hydrochloride tape with abrasive and twisting the tape into thread.

INSULATION. L. S. Meyer (to Plaskon Co., Inc.). U. S. 2,273,367, Feb. 17. Dispersing calcium sulfate (as a foam stabilizer) in an aqueous solution of a urea resin and beating the slurry into a froth.

BIGUANIDE RESINS. J. K. Simons (to Plaskon Co., Inc.). U. S. 2,273,382, Feb. 17. Condensing formaldehyde with a biguanide derivative such as aryl-substituted iminodihydro- or diiminotetrahydrotriazines and heating the product in presence of acid to form an infusible resin.

CHEWING GUM. W. S. Traylor (to Hercules Powder Co.). U. S. 2,273,425, Feb. 17. Compounding rubber, chicle or a resin with ethylcellulose to make chewing gum.

PLASTICIZED FILMS. K. Desamari and R. Hebermehl (to I. G. Farb. Akt.). U. S. 2,273,436, Feb. 17. Plasticizing chlorinated rubber, polyvinyl chloride or chloroprene films with an acetal derived from an aryl ether (or thioether) of a glycol.

JOINING SURFACES. J. E. Snyder (to Wingfoot Corp.). U. S. 2,273,452, Feb. 17. Joining rubber hydrochloride films or foils in selected areas with the aid of a solvent and heat.

LAMINATED SHEETS. R. P. Dinsmore (to Wingfoot Corp.). U. S. 2,273,466, Feb. 17. Joining a sheet of oriented elastoplastic film to a sheet of similar but unoriented film for improvement of tensile and impact tensile strength.

INJECTION MOLDING. R. W. Dinzl (to Watson-Stillman Co.). U. S. 2,273,516, Feb. 17. An injection molding machine in which a delivery connection between a die and the injector is sealed under hydraulic pressure.

INSULATED WIRE. W. E. Gloor (to Hercules Powder Co.). U. S. 2,273,518, Feb. 17. Coating conductor wire with a melt of thermally stable ethyl cellulose blended with rosin.

CONTAINERS. W. C. Calvert (to Wingfoot Corp.). U. S. 2,273,560, Feb. 17. Paper is faced with a thermoplastic resin film and then with a layer of thermoplastic bonded to the first film by heat.

RUBBER-RESIN PRODUCTS. C. A. Redfarn and P. Schidrowitz (to British Rubber Producers' Research Assoc'n). U. S. 2,273,593, Feb. 17. Heating rubber, maleic anhydride and a phenol together.

EXTRUDING PLASTICS. E. J. Roth (to Joe Lowe Corp.). U. S. 2,273,595, Feb. 17. In an extrusion machine pressure is applied to the plastic by compressed air in a chamber which can be vented to the atmosphere.

PLASTIC MIRROR. W. F. Bartoe (to Rohm and Haas Co.). U. S. 2,273,613, Feb. 17. Silvering the surface of an acrylate resin molding by action of alkali on a silvering solution.

LAMINATED FOILS. R. Wallach (to Sylvania Industrial Corp.). U. S. 2,273,677, Feb. 17. Joining cellulosic foils together with an ethyl cellulose cement.

VINYL RESIN SOLUTION. R. F. Wolf (to B. F. Goodrich Co.). U. S. 2,273,682, Feb. 17. Lowering the gel point of vinyl chloride resin solutions by using a blended solvent, e.g., acetylacetone and furfural.

DECORATED FOILS. K. Feuerstein (to Rohm and Haas Co.). U. S. 2,273,700, Feb. 17. Forming designs on thermoplastic sheets from pigment pastes deposited in the depressions of a design in a plate.

INJECTION MOLDING. I. B. Lawyer (to Hydraulic Development Corp.). U. S. 2,273,713, Feb. 17. Use of hydraulic pressure and a system of springs for opening, closing and controlling mold sections.

SLIDE FASTENERS. S. Quisling (to Talon, Inc.). U. S. 2,273,732, Feb. 17. Making slide fastener elements from a fibrous phenolic resin molding composition.

BRAKE LINING. W. Nanfeldt (to World Bestos Corp.). U. S. 2,273,770, Feb. 17. Compounding sulfurized linseed oil with pigments, fillers and asbestos and then with more asbestos and a cresol-formaldehyde resin.

WAX BLENDS. H. R. Dittmar (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,273,780, Feb. 17. Blending waxes of the ester type with acrylate or methacrylate ester polymers.

UREA RESIN. J. F. Olin (to Sharples Chemicals, Inc.). U. S. 2,273,788, Feb. 17. Condensing formaldehyde with urea and butylurea (or a higher alkylurea) to form a soluble thermosetting resin.

POLYSTYRENE. I. Allen, Jr. (to Union Carbide and Carbon Corp.). U. S. 2,273,822, Feb. 24. Polymerizing styrene to a molecular weight above 40,000 and masticating the product to improve molding behavior.

PLASTIC BINDERS. H. G. Barrett (to Plastic Binding Corp.). U. S. 2,273,824, Feb. 24. Apparatus for applying plastic binder strips to sheets with the aid of a mandrel around which the strips are looped.

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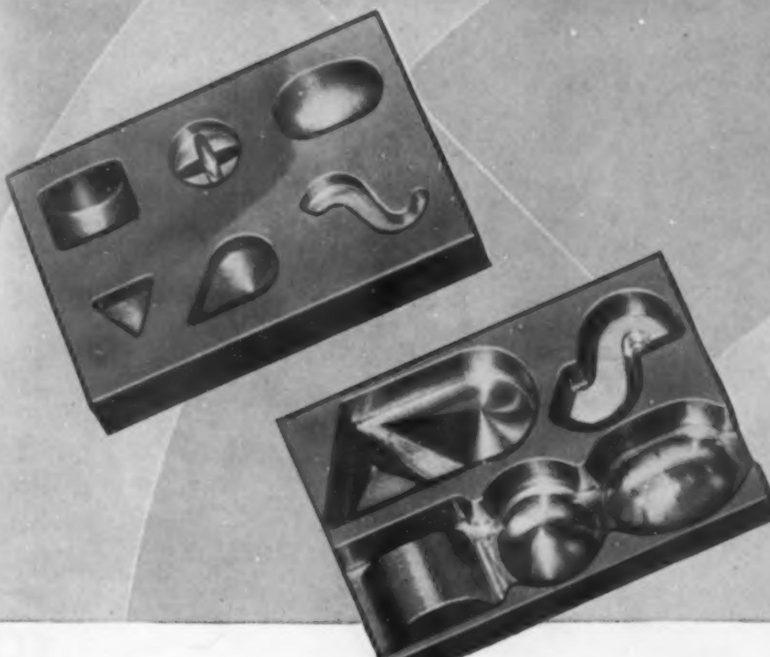

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by J. Delmonte

Penton Publishing Co., Cleveland, 1942

Price $7.50 — **601 pages, 113 illustrations**

The first edition of this book was reviewed in the October 1940 issue of MODERN PLASTICS. The preparation of a second edition at this early date indicates not only that the book met with a ready response, but also that the author and publisher intend to keep it abreast of a rapidly moving industry. Among the newer plastics discussed in this edition are the polyamides, melamine-formaldehyde resin, polyvinylidene chloride and methyl cellulose. New information is presented on plastic-bonded plywood, adhesives, extrusion molding and synthetic rubbers. The new edition is again a high quality job, both in contents and format.
G.M.K.

Proceedings of the 13th Semi-Annual Eastern Photoelasticity Conference

W. M. Murray, Editor

Published by the Eastern Photoelasticity Conference, Room 1-321, Mass. Institute of Technology, Cambridge, 1941

Price $2.00 — **130 pages**

Advances in this important field of science relating to the quantitative measurement of stresses in engineering models are reported in the 18 papers published in these proceedings. The survey of the Committee on Materials Research on the properties of the available commercial plastics suitable for this work is of particular interest. The paper describing the equipment and technique employed at the photoelastic laboratory of the Bureau of Reclamation, U. S. De partment of the Interior, Denver, Colorado, is also noteworthy. This laboratory was established in 1934 to assist in the design work on the Grand Coulee Dam project. The transformation of the photoelastic method from an academic research tool to a source of stress-analysis data of practical engineering value is the keynote of this conference report.
G. M. K.

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★ COMPLETE 1942 LINE OF THOR PORTABLE ELECTric Tools is described in an attractive 64-page catalog issued by the Independent Pneumatic Tool Co., 600 West Jackson Blvd., Chicago, Ill. Containing four major sections, the book gives complete descriptions, specifications and prices on the entire line of universal type electric drills, drill stands, screw drivers, nut setters, tappers, saws, hammers, nibblers, grinders, sanders, polishers and electric tool accessories.

The Condensed Chemical Dictionary, 3rd Edition

Thomas C. Gregory, Editor

Reinhold Publishing Corp., 330 W. 42nd St., New York, 1942

Price $12.00 — **756 pages**

This is a reference volume containing essential data regarding chemicals and other substances used in commerce, plant and laboratory. Over 6000 new items, including a large number of chemical specialties sold under trade or brand names, have been added in this edition, making a total of over 18,000 items. Many of these relate to synthetic resins, fibers, rubbers and organic chemicals which have become commercially important since the previous 1930 edition. The inclusion of various tables of physical constants and definitions of units, a guide to pronunciation of chemical names and a survey of the effects of wartime on chemical prices serves to make this book a very complete and convenient source of information in its field.
G.M.K.

★ "CELANESE IN WAR" TELLS THE STORY OF THE products of Celanese Corp. of America, 180 Madison Ave., New York City, in their new militant rôles. Full page photographs illustrate dramatically the uses to which these materials are put; e.g., marching midshipmen at Annapolis wear Celanese lined overcoats; long rows of training planes for flying cadets have windshields and cockpit covers of Lumarith; a warm blanket which will go to sea is woven of Lanese yarn; a scouting plane radio operator flashes a message over his transmitter, which has Celanese insulated wiring. In World War I, the booklet points out, Celanese provided the "wing dope" for Allied planes.

★ A NEW CATALOG, NO. 40, PUBLISHED BY JOHN Hassall, Inc., 402 Oakland St., Brooklyn, N. Y., contains a variety of cold forged specialty inserts, special nails, escutcheon pins, rivets, annular threaded screws, drive screws, fluting and knurling, machine screws and secondary operations. This company specializes in custom parts in small or large volume. The catalog also contains very useful tables. Due to the present shortage of screw machine capacity, such inserts and many parts can be designed for upset work with lower costs and quicker delivery.

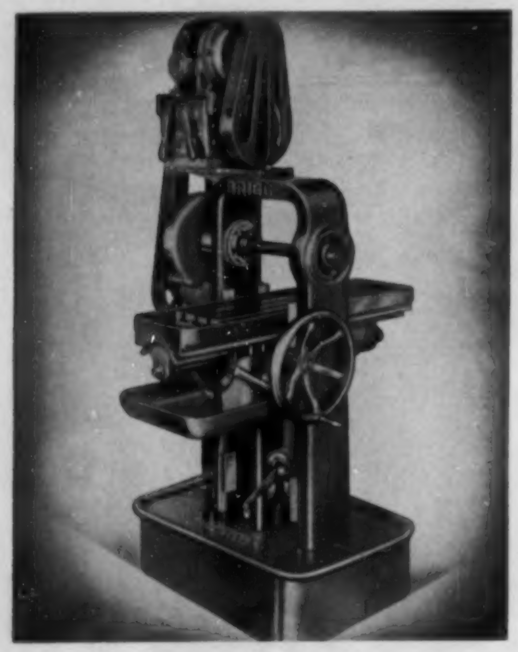
★ A COLLECTION OF STORIES FROM THE 1941 ISSUES of the Du Pont Magazine has been published by E. I. du Pont de Nemours & Co., Inc., Arlington, N. J., under the title "Du Pont Plastics in the Headlines." Designed to answer the question, "Where are Du Pont plastics used?" the group of stories selected describes the rôle of plastics in a variety of fields, and is fully illustrated.

★ L. ALBERT AND SON, AKRON, OHIO, HAVE ISSUED A loose-leaf catalog of machinery which they have acquired and rebuilt for the rubber and plastics industries. Banbury mixers, mills, calenders, tubing machines, dryers, vulcanizers, pumps, compressors, hydraulic presses and various pieces of laboratory equipment are listed. A 27-page section of engineering tables is included.

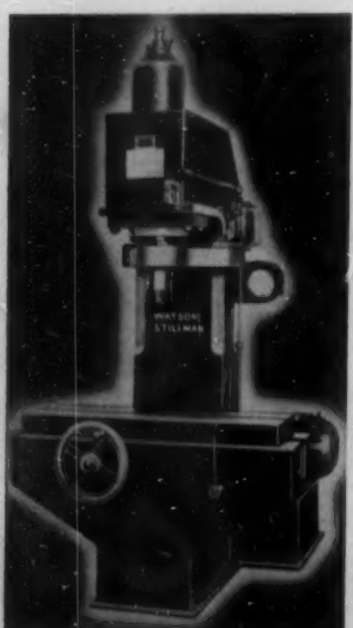
★ DENISON ENGINEERING CO., 119 W. CHESTNUT St., Columbus, Ohio, puts out a letter-folder descriptive of their HydrOILic equipment. Presses, pumps, power units and control valves manufactured by the company are illustrated and described.

★ TO FACILITATE INTRAHEMISPHERE TRADE, THE American Foreign Credit Underwriters Corp. of New York and Chicago has issued a revised edition of their Market Guide for Latin America. Some 55,000 importers, manufacturers, distributors and sales agents in South and Central America and the West Indies are listed, together with their addresses, lines of business and capital and credit ratings.

Machinery and Equipment



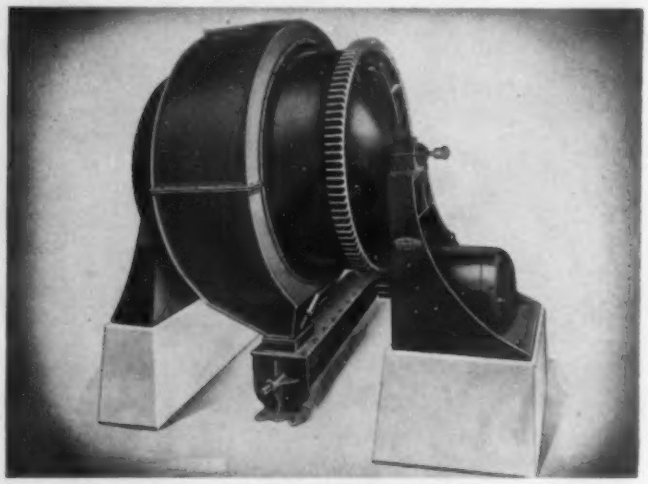
★ SUCCESSOR TO THE ORIGINAL BRIGGS MILLING machine is the A-2 Briggs miller (above) manufactured by C. C. Bradley & Sons, Inc. Retaining the salient points of the old machine, the new miller adds such features and refinements as a hydraulic feed table, new type of spindle, motorized unit drive giving 8 spindle speeds, lateral calibrated adjustment of spindle, calibrated table elevation and spindle reverse. It is claimed to make heavy cuts on straight production work without chatter, with cutter rotating in either direction, and to make climb milling practical on many types of metal. The machine is designed primarily for the manufacture of parts from hard steels where rapid and accurate milling is desired.



★ TO SPEED UP THE straightening of rods, bars, tubes and structural shapes, Watson-Stillman Co. offers a 50-ton straightening press (left). A manually movable work table 4 ft. by $14^1/_2$ in. with a 24-in. travel governed by a large handwheel positions the work. The machine has a 20-in. opening, 14-in. stroke and 12-in. gap. Speeds per minute: advance, 109 in.; pressing, 18 in.; return, 90 in. Control is by a hand lever.

★ FOR PROTECTION AGAINST THE INHALATION OF pneumoconiosis-producing and nuisance dust, the DeVilbiss Co. has brought out its new MSD respirator. A small compact cartridge, measuring only $2^7/_8$ by $1^1/_2$ in. and weighing but one ounce, provides more than 41 sq. in. of breathing and filtering area. Air enters filter housing only through louvers which open downward and stop heavy flakes and fragments before they reach the filter, which is of multi-vane construction, easily cleaned by air-dusting gun or nozzle. The soft molded rubber respirator body is designed to fit any type of facial contour. Claimed to be light, easy to breathe through, comfortable to wear and simple to clean, the device has the approval of the U. S. Bureau of Mines.

★ A NEW DEVICE FOR SOLDERING ELECTRIC WIRE splices is the Jigger, a small compact unit containing the exact amount of 50–50 solder and flux hermetically sealed within a waterproof heat-generating shell. The wire splice is pushed into the Jigger and a lighted match applied, igniting the shell and heating the solder, which flows into the splice. The burnt shell falls away, leaving the soldered splice. Jiggers, Inc., is the manufacturer.



★ TO MEET THE INCREASING DEMAND FOR GRINDing or processing materials that must not in any way be contaminated by the metal of which the mill is constructed, and in order to control also the operating temperature conditions, Abbé Engineering Co. has recently built a complete, all stainless steel unit which meets such specifications. This particularly meets the needs of the plastics industry in grinding various types of resins for molding compounds, it is said. In the mill illustrated above, the cylinder is of stainless clad steel welded to stainless clad steel heads. Inside the cylinder a series of rounded baffle bars are welded to produce a wave-like interior surface to provide the required cascading action for the material and grinding medium during the rotation of the mill.

To cool the mill during grinding (or heat it if the process so indicates) dished heads are welded to the outside of the mill heads and a connection is supplied to the cooling water (or steam) jacket surrounding the cylinder which is provided with baffles to effect uniform distribution of the cooling (or heating) medium A rotary joint at one end of the mill permits the introduction of the heating or cooling medium to the jacket while the mill is running. The heating or cooling medium is removed at the opposite end through a similar rotary joint.

Government and Industry

★ A FUNDAMENTAL CHANGE IN THE PRIORITIES system was announced on Mar. 21 by J. S. Knowlson, Director of Industry Operations. As rapidly as new orders can be put into effect, blanket priority ratings (the old "P" orders) will be replaced by Production Requirements Plan ratings. Under the new system, a company makes a single application for priority assistance covering all of its estimated materials needs over a 3-month period. Ratings will be assigned on the basis of the indicated importance of the company's product to the war effort or to essential civilian needs, thus giving the WPB closer control of the distribution and use of all scarce materials. The changeover from blanket ratings will be accomplished over a period of three months, and each industry will be notified as to the date by which the change must be completed. A modified and simplified version of the plan will be available for small firms whose business is less than $100,000 annually.

★ A SERIES OF REGIONAL CONFERENCES OF PRODUCERS of cotton linters in southern States was held during March to map out a production program for the coming season. The series was arranged by Edgar L. Pearson, Chief of the Cellulose Unit of the Chemicals Branch, WPB.

★ A PRINTED COMPILATION OF PRIORITY ORDERS and forms is now available for distribution by the Public Service Section, Inquiry Division, Room 1501, Social Security Bldg., Washington. It is called "Priorities in Force," and is an alphabetical listing of all orders in the M, L, P, E and Suspension series issued by the Bureau of Priorities, Division of Industry Operations, WPB, through Feb. 15, 1942. Supplements will henceforth be issued weekly to keep the listing up to date.

★ THE OFFICIAL PLAN BOOK FOR THE PRODUCTION drive now being conducted by the WPB in cooperation with the Army, Navy and Marine Corps has been distributed to industrial plants throughout the U. S. engaged directly or indirectly in war production. The plan stipulates the organization of a plant labor-management committee which will join with the Government in the effort to increase and accelerate the output of war material. Care of tools, breakdown prevention, maintenance and repair, good lighting and waste avoidance are among the matters which will be the particular charge of the committee.

★ THE WPB HAS BANNED MANUFACTURE OR SALE of gas masks and anti-gas devices for protection against enemy attack unless such masks and devices are on order by Government agencies, including the Office of Civilian Defense, and are built to Army Chemical Warfare Service specifications. Limitation Order L-57, issued Mar. 3, is designed to halt sales of unapproved gas masks to the civil population. The order also prohibits the sale of, among other things, any laminated cloth, laminated glass or plastic lens, or synthetic rubber for use in unapproved masks. It does not apply to masks for non-military use (such as fire-fighting, mining, industrial, scientific masks), provided they are advertised and sold for these purposes.

★ THE DIRECTOR OF INDUSTRIAL OPERATIONS has warned manufacturers of cutting tools that after July 1 they must submit applications for materials under the Production Requirements Plan, using PD-25 A forms. Preference Rating Order P-18-a, under which they are now operating, will expire July 1. Use and distribution of cutting tools are under the direction of Supplementary Order E-2-a, which forbids their delivery except in connection with defense orders bearing preference ratings of A-10.

★ ON MAR. 3 THE DIRECTOR OF INDUSTRY OPERATIONS announced an amendment to Preference Rating Order P-89, covering maintenance, repair and operating supplies for the chemical industry, which redefines the term "operating supplies." Up to the present time, no company has received permission to operate under the terms of the order because applications for serial numbers indicated that the order as originally issued was too broad in its coverage. The amended order defines operating supplies as materials essential to the operation of the producer's plant, including (but not limited to) lubricants, fuels, catalysts and small perishable tools. Specifically excluded are materials physically or chemically incorporated into the producer's products, and material other than catalysts which enters into the chemical reaction necessary to the manufacture of the producer's products. Washes, solvents, extractions, etc., are also excluded. Serial numbers will soon be issued under the amended order to enable companies engaged in the production of war chemicals to take advantage of its provisions.

★ THE TOOLS BRANCH, PRODUCTION DIV., WPB, has requested that owners of idle machine tools make them available for sale so that they will reach plants engaged in war production. All information regarding such tools should be forwarded to the Available Used Tools Section of the WPB in the Social Security Bldg., Washington. Such information should include make, type, size, description, age, serial number and present location of the tool. G. C. Brainard, Chief of the Tools Branch, said that a recent recording of tools in the possession of used machine tools dealers resulted in the listing of approximately 40,000 idle machines, many of which have since found their way into war production.

★ A SHORTAGE OF COTTON BAGS FOR AGRICULTURAL and chemical products has developed because of increased demand of the Armed Services for cloths such as burlap and osnaburg, and decreased supply caused by the war in the Far East. Order M-107 of the WPB, issued Mar. 10, by assigning a high preference rating (A-2) to all orders for such fabrics, is expected to result in increased production.

★ TO INSURE THE UNINTERRUPTED SUPPLY OF WAR materials, committees representing the Army, Navy and the Office of Civilian Defense will be established in each of the nine regions to assist local authorities in identifying Army and Navy plants for special protection, James M. Landis, Director of the OCD, has announced. Although inspection jurisdiction in air-raid matters in Government-owned plants and in privately owned plants having important Army and Navy contracts rests, respectively, in the War and Navy Departments, the OCD issues instructional matter on air-raid protection for industrial establishments, and local authorities are instructed to give such plants special treatment.

★ U. S. COMMISSIONER OF EDUCATION JOHN W. Studebaker has announced a series of 50 sound films to be produced by the Office of Education, Federal Security Agency, with the purpose of assisting workers to understand more thoroughly the courses being given in American vocational schools. Films will be reproduced in 16-mm. size and made available at low cost to defense training centers, vocational schools and industries offering apprentice training. The entire series presents a detailed course in the handling of machine tools in precision work, several films each being devoted to engine lathes, precision measurements, vertical boring mills. milling machines, etc. In every instance, the machine itself rather than the operator is the subject of the film. Castle Films, Inc., is the distributor.

AMERICA'S ANSWER—PRODUCTION

Two-ounce capacity H-P-M Hydraulic Injection Plastics Molding Press.

Thirty-six ounce capacity H-P-M Hydraulic Injection Molding Press.

TIMKEN Bearings are rolling for Victory in every industry—new and old. They'll keep rolling for prosperity after Victory.

As new industries come into being, Timken Tapered Roller Bearings find many opportunities for aiding in their development. This has been going on for more than 40 years. The latest instance is the plastics industry which, while one of the newest, also is one of the most progressive.

Presses are predominant in plastics production and many new adaptations of the hydraulic principle have been made to meet the industry's specific needs.

Out of its long experience in the design and manufacture of hydraulic presses, the Hydraulic Press Mfg. Co., Mount Gilead, Ohio, has produced a range of plastics injection molding presses of from 2 to 36 ounce capacity. All are powered with the H-P-M Hydro-Power Radial Piston Type Pressure Generator equipped with Timken Bearings.

The manufacturer ascribes the efficiency of this unit largely to the positive and accurate separation between rotor and central stationary valve pintle provided by preloaded Timken Roller Bearings. Timken Bearings also are used at other important points in the pump.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TO ASSURE VICTORY

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

Manufacturers of Timken Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; Timken Alloy Steels and Carbon and Alloy Seamless Tubing; and Timken Rock Bits.

Sectional view of the H-P-M Hydro-Power Radial Piston Type Pressure Generator equipped with Timken Bearings.

In the plastics picture

★ THE ANNUAL SPRING MEETING OF THE SPI WILL be held May 3, 4 and 5 at the Homestead Hotel, Hot Springs, Va. The application of plastics to war production will be the principal topic under discussion, and speakers will be drawn from the industry, the armed services, Government bureaus and the Fourth Estate.

★ SEVERAL COMPANIES IN THE PLASTICS INDUSTRY recently initiated a plan for recognizing and appropriately awarding outstanding accomplishments on the part of workers and plants within the industry. Awards which have been established will be made at the spring meeting of the Society of the Plastics Industry, and are as follows:

1. The E. F. Bachner award for remarkable achievement in tool construction. Prize $50.
2. The M. M. Makeever award for outstanding achievement in compression molding a phenolic part. Prize $50.
3. President's award for outstanding achievement in injection molding a thermoplastic part. Prize $50.
4. The Cyanamid award for outstanding achievement in compression molding a urea-formaldehyde part. Prize $50.
5. The Frank Shaw award for outstanding achievement in running a transfer molded job. Prize $50.
6. The G. A. Johns award for outstanding achievement in cold molding. Prize $50.

All awards will be made by the SPI committee to wage earners on an hourly basis only, and all such employees of companies within the industry are eligible for consideration.

★ THE DETROIT RUBBER AND PLASTIC GROUP meeting held at Detroit on February 27 heard a paper on "Rubber and Plastics in the Aircraft Industry" by George DeBell, formerly of Glenn L. Martin Co., now Chief Engineer of the Thomas Mason Corp., Stratford, Conn. Approximately 150 persons attended the meeting. Mr. DeBell's speech will be reprinted in full in an early issue of MODERN PLASTICS.

★ WAYNE CHEMICAL PRODUCTS CO. OF DETROIT has developed a transparent coating for metals which it calls Kemifilm. Composed of resins and cellulose dissolved in acetates and coal tar solvents, the new coating is claimed to be elastic, not subject to cracking and chipping and free from stickiness. Its makers announce that it deposits a coating somewhat like photographic film which is less than .001 in. thick, and dries so quickly that objects may be handled in from 3 to 5 minutes after it has been applied. The product is now being tested for the replacement of hard-to-obtain metallic coatings.

The John Wesley Hyatt Award Committee is now considering candidates for the 1941 John Wesley Hyatt Award. This recognition will go to the individual whose achievement during the year just passed is considered by the committee to have been of outstanding service to the plastics industry. Firms desiring additional copies of the questionnaire which must be filled out for each candidate whose name is submitted to the committee may obtain them from the committee secretary, L. T. Barnette, 122 East 42nd St., New York City. All questionnaires must be in the hands of the committee by noon of April 30.

★ THE PLASTIC INDUSTRIES TECHNICAL INSTITUTE, which conducts classes for the study of plastics in Chicago and Detroit, is now enrolling students for a new forum class to be held at 5 Commerce St., Newark, N. J., under the supervision of Dr. J. P. Trickey, assistant technical director of the Institute. The group will meet two evenings a week for 20 weeks. Cleveland, Ohio, will soon have a similar study forum, meeting at 1414 Williamson Bldg.

★ GEORGE H. RICHARDS, FORMER SECRETARY AND treasurer of Celluloid Corp. of America, has been made general manager of the recently merged Celanese Celluloid Corp., 180 Madison Ave., New York City.

★ THE THIOKOL CORP. HAS ANNOUNCED THE PURchase of two large sections of the former Murray Rubber Co. plant in Trenton, N. J. The Thiokol company will use the newly acquired units in the manufacture of special synthetic rubber latex to go into production of war equipment.

★ DR. C. F. RASSWEILER, DIRECTOR OF RESEARCH at Johns-Manville, has been made a vice-president of that corporation. Dr. Rassweiler will continue in charge of J-M's research and development activities.

★ J. B. WIESEL, DIRECTOR OF SALES, CELLULOSE Products Dept., Hercules Powder Co., has been appointed adviser to J. B. Davis, Chief of the Protective and Technical Coating Section, WPB, in charge of the allocation of nitrocellulose and ethyl cellulose. Mr. Wiesel will divide his time between the WPB and the company.

★ NEW YORK OFFICES OF AMERICAN INSULATOR Corp., custom molder, have been moved from 101 Park Ave. to 405 Lexington Ave.

★ A. H. CIAGLIA HAS BEEN ELECTED VICE-PRESIdent and technician in charge of production of Dumor Plastics, Inc., Atco, N. J.

★ PLASTIKON CO., EXTRUDERS OF ALL TYPES OF thermoplastics, will henceforth be known as National Plastic Products Co., and will be located at 100 McPhail St., Baltimore.

★ W. P. YORK, INC., OF AURORA, ILL., FOR YEARS designers and manufacturers of display materials, have recently been liquidated and the property leased to the Elgin National Watch Co. for war material production. Mr. York has joined W. L. Stensgaard & Associates, Inc., of Chicago, as an executive.

★ A NEW PHENOLIC MOLDING COMPOUND CLAIMED to have a very low power factor (0.07 at 1000 K. C.) and high dielectric breakdown and fatigue has recently been introduced by Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y. This material, available in natural color only, was especially developed for radio parts as condensers, crystal holders, etc. It is said to be easy to handle in compression molds.

★ BECAUSE CRUDE RUBBER IS NO LONGER AVAILable for hand stamps, B. F. Goodrich Co. is manufacturing a new line of compounds made from Ameripol (a synthetic rubber developed in its own laboratories) and compounds of reclaim rubber which can be used in making hand-daters, logotypes and toy stamping sets.

★ BAKELITE CORP., UNIT OF UNION CARBIDE AND Carbon Corp., announces the development of a new impact-resistant phenolic molding plastic, Bakelite Phenolic Resin XM-15000. Developed to meet the need for a material of this description that may be preformed on automatic tabletting machines, the new resin is said to have approximately twice the shock resistance of general purpose phenolics and comparatively good water-resistance. (*Please turn to next page*)

Plaskon opens new laboratory

SO GREAT is the emphasis today upon increased industrial output that there is a tendency to overlook the preliminary research work without which there would be no production at all. The plastics industry, in particular, is dependent upon its laboratories, since plastics themselves are products of the test tube and the crucible. Even in the midst of their accelerated war production program, therefore, plastics men throughout the country found time to attend on Feb. 27 the dedication ceremonies of the new engineering and research laboratory opened by the Plaskon Co., Inc., of Toledo, Ohio; and to pay their respects to Dr. A. M. Howald, the laboratory's Director of Research. Dr. Howald's work at the Mellon Institute of Industrial Research at Pittsburgh, Pa., some 13 years ago, resulted in the urea-formaldehyde molding compound known today as Plaskon.

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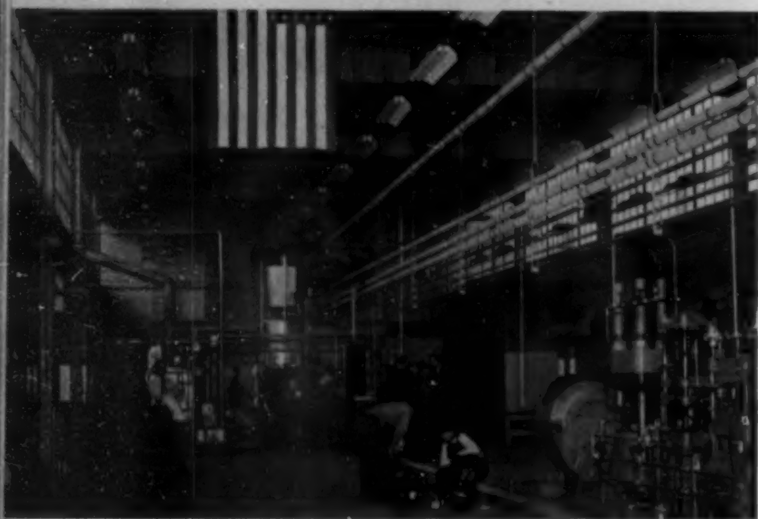

The laboratory building (Fig. 1) is located out of town, several miles from the Plaskon manufacturing plant, in order to secure undisturbed quiet for the staff, and to preclude the interruptions which are inevitable in normal city life. This modern laboratory, 90 by 150 feet, is not the largest in the world, though its builders believe it to be one of the most important; and its 18,000 sq. ft. of space (second story in forepart of building adds 3000) have been carefully laid out with its specific functions in mind. It was planned by the laboratory men themselves to meet their needs.

The first and biggest departure they made from the conventional was in the relative amount of space allocated to the engineering section and to the pilot plant. Ordinarily, the strictly research laboratories get 85 to 90 percent of the space, and engineering and pilot plant get what's left. In this laboratory, engineering and pilot plant get 43 percent of the area, research laboratories get approximately 30 percent (because they need less), and the balance is allotted to office and library facilities.

Second unusual feature is the physical arrangement of the various departments. The big engineering and pilot plant section is in the center, and every separate laboratory opens directly on it, separated from it only by a glass partition. The engineering hall (Fig. 2) is, in a strict sense, the central point on which all laboratory research focuses, in theory as well as in actual fact.

In order to obtain the best possible concentration on a given problem, each laboratory has been set up to deal with a specific use of urea-formaldehyde resins and is staffed by separate personnel. Thus the staff of one laboratory works on problems concerned with the use of urea-resin adhesives. In another laboratory, a different staff is conducting research on the employment of resins in paints, lacquers and other surface coatings;

***1**—Modern laboratory building as it appeared on opening day. **2**—View of the huge engineering hall. **3**—Portion of the molding compound research division. **4**—Rubber roll glue spreader for investigating resin adhesives*

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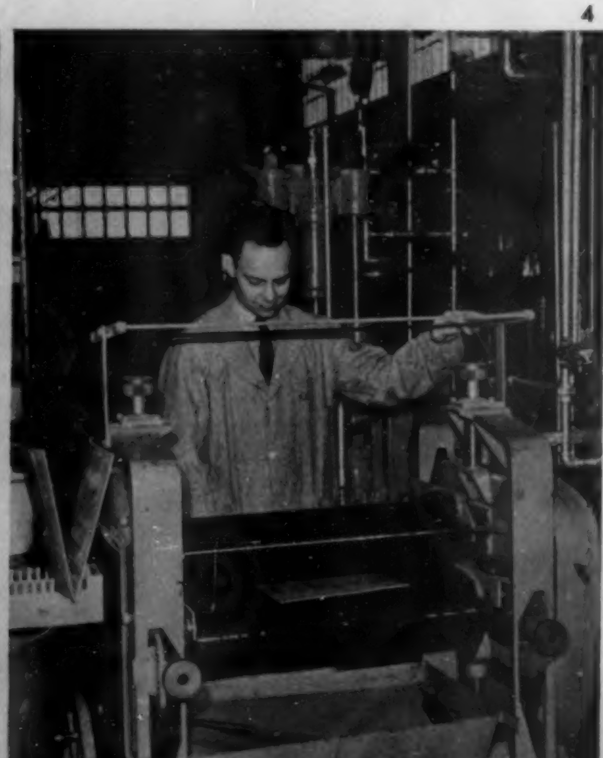


SPECIALLY DESIGNED FOR Plastics!
Eliminates Tapping and Threaded Inserts ... Prevents Fracturing!
End view showing 70° cutting edge.
New Test Kit!
SHAKEPROOF
TYPE 25
Thread-Cutting Screws
Now, plastic parts can be fastened securely without danger of fracturing. Shakeproof engineers have developed a thread-cutting screw with fewer threads per inch and an extra wide slot which produces an acute 70° cutting edge. When driven into plastics, this screw cuts its own thread without setting up severe internal stresses, and the chips created are deflected into the slot cavity which prevents packing and assures easy driving. With the Shakeproof Type 25 Thread-Cutting Screw, separate tapping operations or the use of threaded inserts is eliminated. And, as each screw remains in the thread it has cut itself, a strong, tight fastening is always certain!
Type 9 Thread-Cutting Screw
Type 9 Thread-Cutting Screw
A handy kit containing samples of Types 2, 9 and 25 Thread-Cutting Screws in a variety of sizes is offered for testing purposes. Try these screws yourself—see how they reduce costs—save time and produce better plastic fastenings. Send for your kit today!
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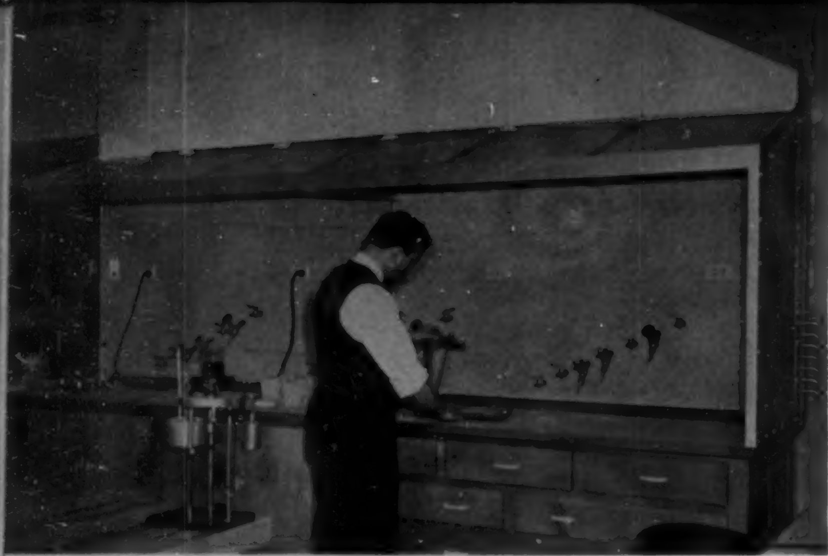
SPRING WASHERS • RADIO AND INSTRUMENT GEARS • ENGINEERED SHAKEPROOF PARTS • SPECIAL STAMPINGS



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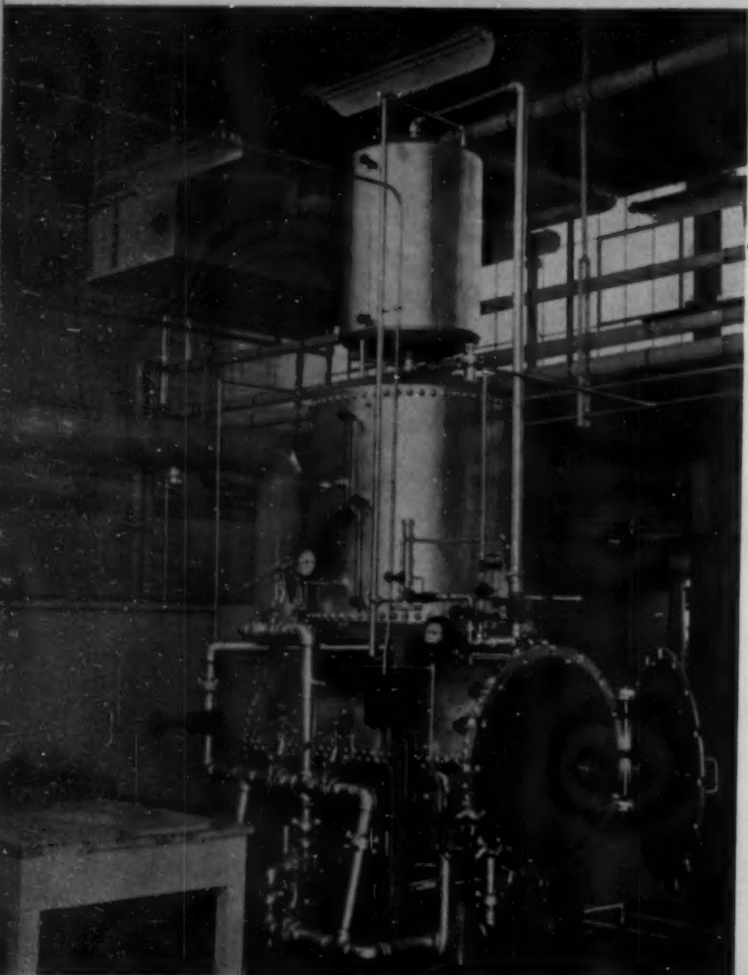
5—Paint testing section showing type of hood employed on experimental work benches. 6—Machine to determine plywood strengths. 7—Experimental autoclave to produce molded articles through use of hot water and air pressure, or steam. 8—Discharging piece from the equipment. 9—Close-up of molded piece and wooden mold used in the bag



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another staff is engaged with molding compounds; a fourth laboratory is set aside for new products; while a fifth department is committed to fundamental research on resins.

Diversification in laboratory work on common problems is carried over into the engineering research department. Each staff, when its experiments have reached the point where an engineering test may be applied, utilizes the equipment in the manner which promises to be most effective in developing the line of attack adopted. The knowledge thus procured by the different staffs both in the laboratory and in the engineering section may be correlated, sifted for techniques valuable to all.

Among the specific innovations which have been devised for the new laboratory are such details as hoods with safety glass above and on both sides, and draft so arranged that it exhausts all fumes without creating any noticeable current of air. Some of the hoods are 16 ft. long, providing space for complete equipment for much experimental work (Fig. 5). In addition, the wall back of each bench and hood has outlets for all of the utilities required in an experiment. Within easy reach are spigots for hot water, cold water, natural gas, inert gas, vacuum and air pressure. At four places along the wall are sockets for both AC and DC electrical appliances.

Among the outstanding pieces of equipment are an aquatherm autoclave for molded plywood experiments and projects (Figs. 7–9); glue-spreaders, presses and testing devices for bonding wood and other fibers together; and a battery of small molding presses (Figs. 3–4). *(Please turn to next page)*

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★ ★ DO YOU WANT HELP ★ ★
PRODUCING FOR VICTORY?

Put GENERAL INDUSTRIES on the Job Molding Plastics Parts

● You run no risk, take no chance, when you turn to General Industries for your molded plastics parts. We have everything it takes to travel along with you in all your requirements. Our plant is one of the largest of the kind in the country. Equipment is efficient and modern, comprising a complete range of machines capable of molding plastics of any type and size. Our experience in molding the widest variety of molded plastics parts for practically every line of industry is assurance that we will take hold of your job and handle it competently, surely, and deliver on time.

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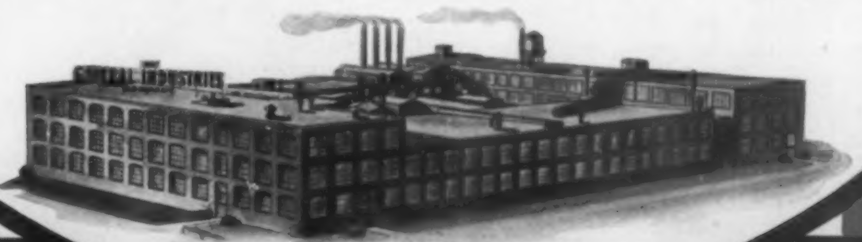
MILWAUKEE . . . . Phone Daly 4057



★ ★ ★ ★ ★ ★

The GENERAL INDUSTRIES Co.
MOLDED PLASTICS DIVISION · ELYRIA, OHIO

The largest of the individual laboratories is that devoted especially to the research on customer problems, and is known as the Technical Service Division (Figs. 5-6). This laboratory is under the supervision and direction of Dr. M. H. Bigelow, like Dr. Howald a former fellow of the Mellon Institute. Technical Service has always been an important activity in plastics, and indications are that it will be even more important as war pressures grow more severe; while post-war conditions will cause it to assume even greater prominence.

The front of the laboratory building houses the offices on the street level. Above them is the technical library consisting of 10,000 volumes, the only technical library of its size in this region, which has been increased by the acquisition of the extensive library assembled by Carleton Ellis. In addition to reading room and other library facilities, a special room has been set aside for the housing of delicate technical instruments, and another to be used as a conference room for staff members.

The building and all of its equipment were shining with newness when 165 notable figures of the plastics industry inspected it on the dedication day. The group of guests had lunched at the Toledo Club, and visited the laboratory in the afternoon. After tours of inspection, they assembled in the library, where James L. Rodgers, President of the company, acting as toastmaster, introduced the speakers.

H. D. Bennett who, as President of the Toledo Scale Co. had established the initial research which led to the development of Plaskon, told of the ideal and wholly theoretical material he had sought, and of how his requirements had been met.

Dr. E. R. Weidlein, Director of the Mellon Institute, the principal speaker, stressed the essential importance of the laboratory in solving today's problems.

Molding tropical tools

(*Continued from page 38*) sections are removed from the mold early to speed up the cycle. This type of porosity may also be caused by insufficient feed of molding powder into the heater, causing the pressure on the material to drop off at the completion of the injection stroke.

The butt end of the handle is molded to shape. The bottom $^3/_8$ in. of a nut which screws on the end of the blade is concealed in the cavity molded in the top of the handle.

The back of the handle is molded flat, as is seen in the illustration, but is ground to insure seating of the handle firmly at the pin holes and around the edges. Since this precautionary grinding was to be done, knockout pins were located on the reverse or flat side of the handles so that any ridges or deformation caused by the knockout pins would be removed during the wet grinding. Two knockouts were used per cavity, for stripping the handles from the pins.

The pins are located in the flat part of the die. The cavities on the stationary half free themselves, due to the all-around draft mentioned above. The knockouts then strip the molded part from the fixed pins on the flat half of the die after the dies are open. A generous taper of the sprue and sharp undercut of the sprue knockout also aid materially in freeing the parts from the cavities when the dies open.

Development of the wide gates

The chief difficulty encountered in molding this piece was the unusually heavy section.[1] Originally, a small gate was planned to facilitate easy trimming. It was noted in the experimental die that excessive deformative shrinkage occurred around the gate. First, higher molding temperatures against longer die closed time were tried. These variables had little or no results, except in the surface finish and appearance of the piece, and did not correct the objectionable shrinkage.

Gates were increased in size three times, with a decided benefit at each trial. The final gate was of the extraordinary dimensions indicated in the illustration on page 38. The final gate is $1^1/_{16}$ in. wide, while the width of the handle itself is $1^1/_4$ in. The gate is $^3/_{16}$ in. thick, while the handle is $^3/_8$ in. thick. Thus more than half the end of the handle is used to gate.

Apparently the heavy gate equalized the shrinkage at the end of the piece, and located the distortion due to the change of section and terminal or differential cooling around the sprue and in the runners.

The large gates cut down on the porosity of the handles, actually increasing the density of the piece about 10 per cent as gaged by material consumption. Naturally the resulting handles were more durable under conditions of field abuse.

The total mold closed time was reduced when the final cycle was worked out for the finished die. On the final cycle the plunger was left in longer and the heater run at a lower temperature than with the smaller gates to ensure that the terminal shrinkage would all take place in the vicinity of the heavy runners. The net effect on the cycle was a saving of about 4 seconds. The cycle with small gates was 44 seconds; with the wide gates illustrated, 40 seconds.

The nozzle used was $^5/_{16}$ in., to allow quick flow of material. The back of the handle is flat, so the material meets no obstructions or step or turn in the runner, but flows freely into the cavity along this flat back plate. This permits a minimum of venting for "breathing," which is often necessary where smaller gates cause convection of the material as it worms into the cavity welding, moving and rewelding.

The broad runners are backed by water passages and maintained at a constant temperature. Thus each shot is exposed to a surface of uniform temperature, which does not slow, cool or mark the initial front or wave of the shot. The result is a thoroughly "knit" piece of molded plastic. The heavy gating eliminates the danger of cracking which might occur if a smaller gate were used, and produces a terminal weld back of the last pin hole when the handle is riveted to the blade.

These wide gates also prevent a small stream of excessively hot material from impinging directly on the pins at the start of the shot, causing invisible strains or objectionable marks to be dragged into the molding, due to this momentary relative chilling.

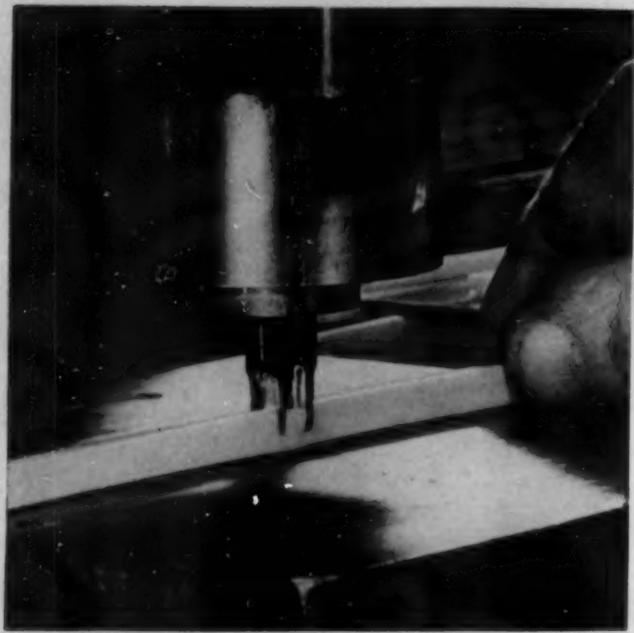
Years ago many die and sand casters learned that shrinkage could be controlled by enlarging gates, and sometimes by addition of risers. These facts are of course known, but not commonly recognized by plastic mold makers, who generally tend to make gates as small as possible, apparently to allow the gates to be trimmed or pared off easily. The molder of this handle, however, tells us he uses risers in several dies to control shrinkage and furnish a knockout point which will not mar the molding.

That gate on this handle is sawed off on an inexpensive circular saw, and ground on a continuous wet belt grinder before being buffed on a cloth buffer with compound.

The machete handle is made on a 6-oz. injection molding machine. The shot, nevertheless, complete with sprue and runners weighs a little over $7^1/_2$ oz. and the cycle is approximately 40 seconds. A combination of ingenious mold design, improvements in molding machinery and in raw materials resulted in an unusually strong, long-wearing handle, economically produced, which will stand up under the strain of jungle weather and rough action.

Credits—Material: Tenite. Molded by Ohio Plastic Co. for Lilley-Ames Corp on a Reed-Prentice injection molding machine.

[1] A more detailed description of techniques employed in heavy section injection molding appeared in the March 1942 issue, page 64.



4

Finding facts and figures

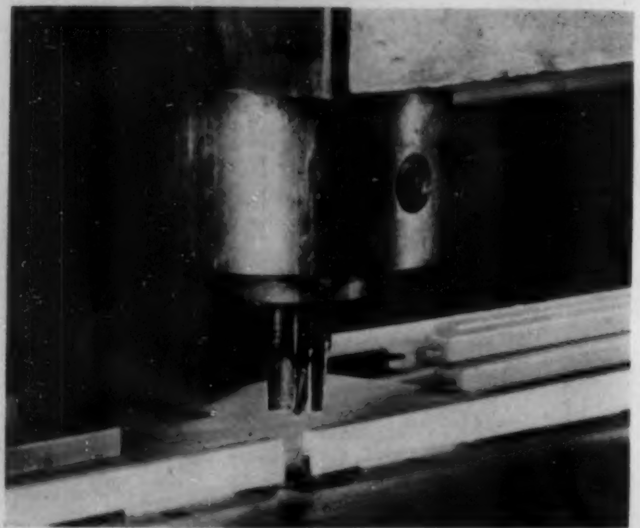
(*Continued from page 36*)

The bottom edges of the cards rest on a corduroy base (Fig. 1, bottom) in the housing equipment and the size of form and grade of stock are optional. This method of housing record forms visibly is the remarkable improvement in the visible equipment industry.

The record cards are not attached by wire, clamp, pocket or other device to the tray or file, but are easily removed for insertion into posting machine or to be laid flat on desk for hand posting.

The utmost flexibility of the visible record system is achieved by its most important component part—namely, the separator or divider which serves to divide the echeloned card banks, and makes possible any desired card size with respect to height, width and paper or card stock thickness. Dividers are made in various heights: 4 in., 5 in., 6 in., 8 in., 10 in., 11 in., 12 in. and 13 in. tall, and in two lengths, 25 in. and 21 in. Special extra large sizes are made to order as well.

The dividers are constructed of a masonite panel, provided at the top with a metal pocket, designed to hold a transparent strip of plastic, which covers the top horizontal margins of the stepped card banks, thus permitting clear vision of signaling and indexing features of thousands of visible record cards at a glance. This strip is $^3/_4$ in. by $25^7/_8$ in., $^1/_2$ in. providing the horizontal visibility, and $^1/_4$ in. being held in the metal pocket. Vinyl strips .020 in. thick were selected for this purpose because they are impervious



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***4**—Savings in manufacture, assembly and better finish are secured by die cutting with interchangeable cutters and automatic stitching. Here the Schramm cutter slices and shapes the plastic end rails. **5**—Completion of the shaped cut. **6**—Close-up of the motor-driven stitcher which sinks a flat wire into the extruded end rail through the clear vinyl top strip. **7**—View of the automatic stitching operation attaching the plastic strip to the panel*

6

7

to atmospheric conditions, such as exposure to extreme cold or heat, and maintain uniformity of shape.

Transparent plastic colored or clear index tabs specially designed for the record card clamp over the vinyl strip. These index tabs placed in one or more positions, provide individually indexed card banks.

In many instances the visible record forms are folded over, and when taken out of equipment for posting, open to surprisingly large sizes. Such variances of superimposed build-ups predetermined by width and card stock used call for utmost accuracy of separation of the card banks, achieved by the end rails affixed to the sides of the divider. These end rails range in thickness from .140 to .280 or more, depending on the requirements of the record.

End rails for the record cards which, due to card capacities, must be held to the utmost precision and accuracy in size, were formerly made of aluminum. At the start of hostilities, realizing the apparent future shortages to be encountered in aluminum, the company engineers instituted a concerted search for a substitute material, particularly concentrating on plastics in order to obtain a variety of colors, and a material which could be extruded in the most desirable lengths and cut with a minimum of waste. Furthermore, it had to be extruded with the utmost precision and in this case held to plus or minus .005 in. Cellulose acetate butyrate was specified and the advent of these end rails (Fig. 2), in colors—not obtainable with aluminum—added another fast reference feature to the visible record system. It made possible visual segregation of various types of records.

New manufacturing methods have been instituted by the company engineers which, due to the versatility of the product, have effected important savings. The cellulose acetate butyrate end rails, in order to function properly, must be shaped on the top and bottom. As was the case with aluminum, they first had to be cut to proper lengths by a band saw, shaped at top and bottom and then clamped on to the divider panel. At first it was planned to attach the end rails by gluing and affixing small brads shaved off the rear, but this destroyed the sheen of the plastic and the shape. A unique series of cutters which operate in a motor-driven punch press were designed to die-cut the top and bottom of the rails and then stitch them to the divider.

These cutters (see Figs. 4, 5) cut and at the same time form the end rails in their desired shapes and lengths. Forty different sizes of end rails must be cut on short notice, and as it is not in keeping with the times to carry an excessive inventory of parts, the cutting operation must be exceedingly fast. A simple interchange of cutters permits a quick change for various thicknesses of end rail.

The next problem was to revise the method of clamping the end rails to the divider panel. For this, the engineers designed a special head to fit into a flat wire, motor-driven stitcher, that would not destroy the wall thicknesses of the end rail, which as mentioned above had to be held at plus or minus .005. This head counter sinks the wire stitch into the extruded plastic strip without preheating of the material, (Fig. 6) and permits the fastening of the end rail to the divider panel with utmost speed and efficiency (Fig. 7). The stitch is adjustable in lengths on the stitcher to conform with the end rail thickness. Since the end rail is slotted to hold the masonite panel, the stitch is driven into top side of end rail, through the panel (first through the vinyl strip at top and then through the masonite board) and further sunk into one-half of the remaining extruded plastic rail. The contracting qualities of the plastic secure the wire stitch in place without a holding turn on the stitch. This stitch is only partly visible on the rear of the divider, which at all times is out of sight, permitting an absolutely smooth appearance on the front of the strip.

In the course of developing the plastic end rails, the company decided that a divider of improved visibility could be made by the use of clear vinyl sheets to replace the opaque section of the panel. The construction of such panels is similar to the standard masonite divider in so far as the extruded plastic end rails are concerned; but in addition the panel has an extruded cellulose acetate butyrate strip or plate at top or bottom.

Interesting to note, in the change-over from aluminum to plastic, is the fact that the company was able to reduce the number of manufacturing man-hours at *a ratio of seven to one*, with an increase in production of 500 percent. The plastic end rails need no finishing, are permanent in color and greatly enhance the function and looks of the equipment.

Credits—Material: Tenite II, Vinylite. VISIrecord extruded end rails by Extruded Plastics, Inc., for Visible Index Corporation

Old records for new

(***Continued from page 48***) smooth off the edges, inspect the finished disks and place them in envelopes ready for sale.

The inspecting process involves two operations. Each record is carefully examined by the press operator and by a final inspector. Later, one record is selected at random from each package of 25 and is played by highly skilled inspectors who are able to pick out imperfections that would be unheard by the average listener. On the rare occasions when imperfect disks are discovered, the presses are stopped immediately.

Records have survived three threats

Recorded music first seemed headed for oblivion in 1905, while it was still an unaccepted industry. Its fate hung in the balance again in 1925, and was threatened for the third time in the lean years of the depression. Reasons for this multiple decline and resuscitation can easily be traced to factors within the industry itself.

A Frenchman, Leon Scott, is credited with the first conception of the phonograph, or "Phonautograph," as he called his new contraption. This was in 1855; but the idea was either too hazy or too poorly presented to secure any financial backing, and the scheme was abandoned.

In 1877, however, the more practical Thomas A. Edison took up the idea and the daydream assumed concrete form. Other engineering pioneers became interested. In 1888, Emil Berliner conceived the idea of pressing a number of records from a master rather than spoiling the original disk by playing it back as his predecessors had done. Ten years later, he showed the device to Eldridge Johnson of Camden, N. J., and a new industry was born.

It was prophetic that one of the first recordings made by the new partnership was entitled, *I Guess I'll Telegraph My Baby*. Their instrument was crude and their results barely recognizable, but the pair was laying the foundation for an expanding organization. The name "Victor" did not appear until 1901, when Johnson was convinced they had won "victory" over their problems. The trademark, the famous Victor dog, was adopted about the same time.

But the phonograph was regarded generally as a toy. People scrupulously avoided the machine and—what was worse—reputable musicians refused to record for it. The break came in 1906, following the signing of Enrico Caruso as a Victor

artist. Popularity of some of the Caruso records still stands untouched in record history.

In 1921 radio came into the picture, not only a new idea but a vast improvement in sound reproduction. Beside it the phonograph, which still used the old acoustic process of the early 1900's, looked pale by contrast. By 1925 millions of talking machines had been relegated to the attic.

Then came the orthophonic machine, tonal equal of the finest radios of the day. It brought with it the realization that radio was not and never could be the musical rival of the phonograph. The two instruments occupied different fields.

It was also about this time that recording itself underwent a tremendous transformation. Disks had previously been recorded through an elongated horn which, because of its ability to concentrate sound, moved the needle over the disk in proportion to the singer's lung power. Now, however, a microphone was employed and the recording done by an electrical process. The results were so startlingly realistic that they could be compared only with the music in the original. Once again records and phonographs were in the sun—and, once again, they were thrust into outer darkness by an outside agency—the depression.

In 1933, Radio Corp. of America, which had taken over the faltering Victor Co., introduced "higher fidelity," a realistic recording system said to be so sensitive that it is claimed capable of reproducing overtones beyond the scope of the human ear. Instruments were redesigned and a record player attachment provided for radio users.

The results are well enough known now. Since 1933 the phonograph record has doubled and quadrupled in popularity, passing all previous high-water marks. The sweeping demand for swing and its offspring, the coin phonograph, returning prosperity, and the demand for certain artists created by radio are some of the factors responsible. Together, the radio and the phonograph record can claim the credit of bringing about a growing American interest in classical music, a rebirth of attention to enduring entertainment.

Laminates for surfaces

(Continued from page 51) core is of 5-ply construction consisting of Ponderosa pine blocks glued together, and to both sides of this plank 1/8-in. hardwood cross banding is veneered with a resin glue. The outer plastic layers insure relatively good water resistance. These veneer panels can be made to look like wood by laminating wood veneers into the surface sheet—ideal for wall paneling. This same company manufactures a plastic sheet veneered on synthetic board. This product is manufactured principally in 5/32-in. thicknesses, although 1/4 and 3/8 in. are available, with sanded back for veneering or with a plain back for wall paneling, wainscoting, ceilings, etc. It consists of a laminated paper-base surface molded to both sides of the monolithic synthetic resinous core.

Still another type of heavy-duty molded-laminated plastic table top material (Fig. 9) is manufactured in one molding process, by which the laminated surface sheet is fused to a synthetic resin-bonded plywood core.[1] This shockproof material is said to be adaptable for indoor and outdoor use.

One of the decorative forms of laminates which has been used for some years is pictured in Fig. 6. Over the fireplace of an all-plywood house recently constructed is a decorative wall of woven mahogany laminate—a thin veneer of rare

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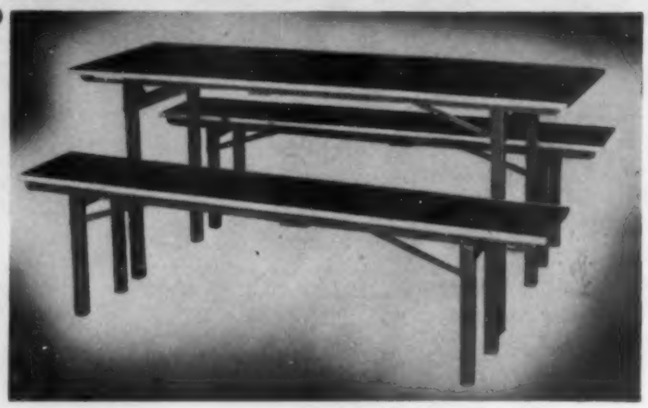


9—Panel interiors with fine natural-wood surfaces are economically produced with urea resin-bonded wood. 10—Durable table and bench tops of the type used for mess quarters are of shock-proof, molded-laminated phenolic

wood woven in an attractive design and impregnated with resinoid in the usual way.

Plastics have also entered the architectural field as a prefinished surfacing material to replace tiled wall and solid colored panels in commercial and professional interiors, garages, laundries, kitchens and bathrooms (see Figs. 7–8). Such wallboard, consisting of urea-formaldehyde plastic surface, heat fused to tempered wood or fibre wall board, will help to meet lumber shortages.

Available in sizes up to 8 ft. long, 5/32 in. thick, these large, virtually wall-size sheets can be sawed, nailed and applied over old or new walls and ceilings. The lustrous finished surface is hard, chemically inert, color stable, stainproof and washable. At a fraction of the cost of ceramic tile, tileboard sheets provide a smart decoration. Scored joint markings, forming 4-in. squares, with "mortar" lines in contrasting color, give the effect of 4-in. tiles set in cement. Solid color and panel sheets with horizontal scoring lines spaced 4 or 8 in. apart running the entire length of the panel, transform shabby outmoded interiors and provide a long-wearing surface that can be rapidly installed.

An attractive type of 3-ply wall paneling with wood facing makes use of an especially prepared urea-resin adhesive (Fig. 10). Sheets 48 in. by 96 in. are made with wood faces only on one side of the board. Backs of the boards are what is commonly known as reject backs. The faces are of the following woods: oak, walnut, mahogany, gum and birch.

These boards are fabricated by coating the core or center of the panel with a urea-resin mixture. The face is laid against one side of the core, the back against the other and the three-ply sandwich laminated under heat and pressure. After removal from the press, the board is cured by a special process which gives it a good degree of flatness and flexibility.

[1] A complete description of military and civilian installations of this molded-laminate will be presented in an early issue of MODERN PLASTICS.

Acrylics for dentures

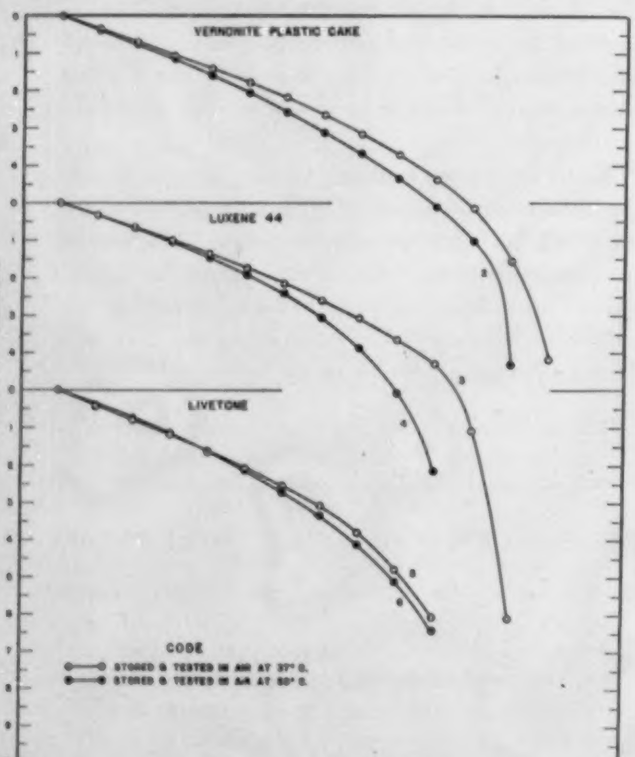
(Continued from page 65)

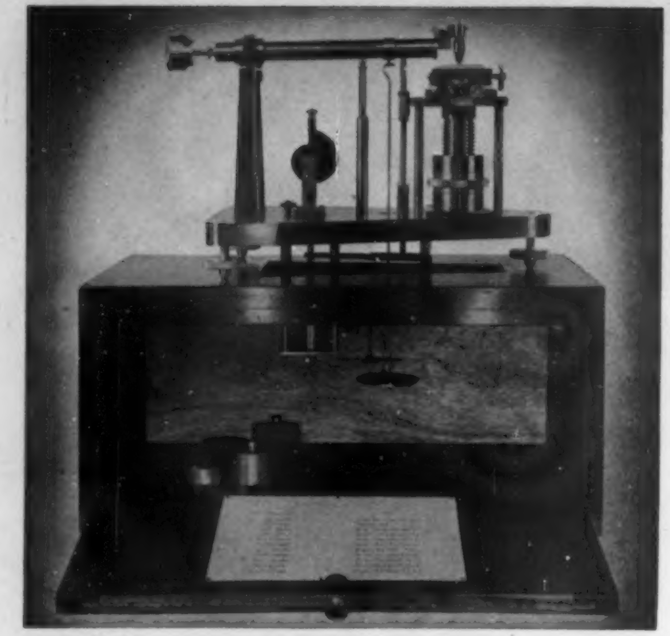
The effect of temperature on the transverse properties of three resins is shown in Fig. 6. Specimens of Vernonite, Luxene 44 and Livetone were tested at 37 deg. C. (99 deg. F.) and 50 deg. C. (122 deg. F.), respectively. The high temperature (curves 2, 4 and 6, Fig. 6), as would be expected, decreased the stiffness of the specimens. Luxene 44 showed the greatest difference, Vernonite next and Livetone the least. The small differences in stiffness may not be significant, and indicate that the resins are probably rigid enough at 50 deg. C. (122 deg. F.) (which may be considered as hot as food can be tolerated in the mouth for any appreciable length of time) to hold their shape in service.

Hardness. The indentation hardness was determined by the Knoop indentation method. Figure 7 shows the Knoop diamond indenter mounted in an instrument built in the Bureau shop. This instrument is a modification of the one used by Knoop, Peters and Emerson.[10] The tests were conducted at 25 ± 3 deg. C. (77 ± 5 deg. F.) using a 50-gm. load and a 5-second contact. The values in Table IV, column 5 (the average of ten or more indentations on dry specimens) are reported in kilograms per square millimeter of the projected area of the indentation. Differences of more than 0.5 kg./mm.^{2} are considered significant. The methyl methacrylate resins varied from 16 to 21 kg./mm.^{2}, while the vinyl-containing acrylics were somewhat softer, more nearly approaching the hardness of Ash's dark elastic rubber.

This method of measuring the resistance of the surface to indentation gives a satisfactory means for evaluating certain elastic properties of resins. For instance, the size of the indentation while the load is on the diamond indenter can be calculated and, when compared with the size of the indentation after the load is removed, will show the elastic recovery of the material. This test can possibly be used to evaluate the resistance of a material to abrasion.

6—***Transverse tests of three denture resins at 37 deg. C. (99 deg. F.) and 50 deg. C. (122 deg. F.), respectively***





7—***Indentation hardness test, using Knoop indenter***

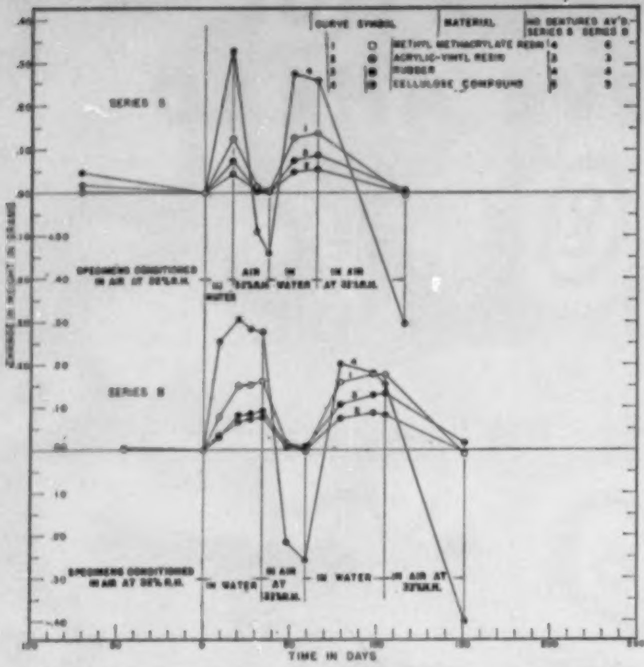
Color stability. The color stability of the denture base material is important. There have been many attempts to use resins developed for industrial applications for denture bases. Until the last few years these have failed almost without exception either because the resins were not color-stable to light or because the pigments or dyes were unstable. Happily, recent advances seem to have corrected these faults so that today the color of most of the resins tested is quite stable.

The materials used in this investigation (Table I) were all exposed to the radiation of a sun lamp (BM 12 General Electric) with a S 1 bulb. The light source is a combination tungsten filament-mercury arc inclosed in Corex D glass, which filters out ultraviolet light below 2800 angstrom units. The air surrounding the specimens was approximately 37 deg. C. (99 deg. F.). After exposure 12 inches from the bulb for 97 hours, only the cellulosic denture material Crystalite showed visual changes. When the same specimens were placed 6 inches from the bulb for 50 hours, Crystalite faded badly, Parfait R and Hecolite darkened, Exelon blank darkened, Exelon powder-liquid darkened slightly, Luxene 44 darkened.

The standard test used in the specification is 24 hours exposure at a distance of 6 inches. The specimens are mounted on a table which revolves at a rate of 33 turns per minute (cf. A.S.T.M. method D 620–41 T for color fastness of plastics to light). The comparisons were made by visual inspection in daylight. All the specimens passed this specification requirement except Exelon blank, which showed darkening. The color stability of dentures in service was satisfactory for the methyl methacrylate resins, which were the only resins observed in a series of practical cases.

Dimensional change: Effect of water on dentures. In order to determine the effect of water on finished dentures, two series of dentures (prepared by two commercial laboratories) were subjected to repeated wetting and drying. All dentures in each series were ordered in pairs to fit a master metal model.

In order to follow the changes that took place in a denture during alternate wetting and drying, the following procedure



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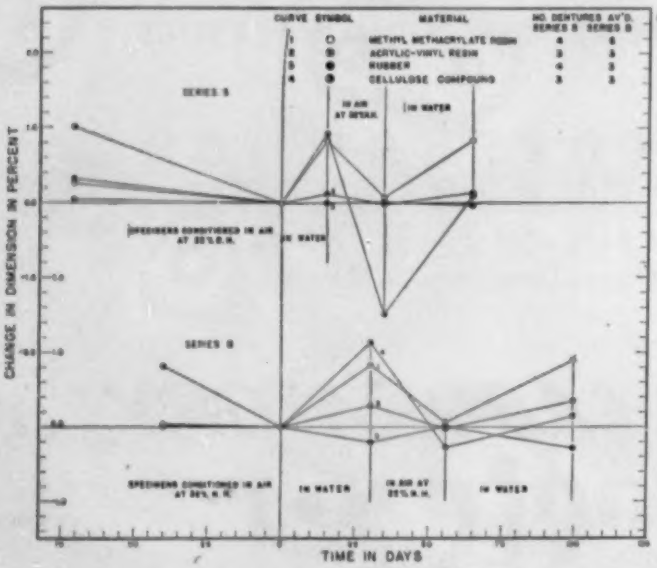

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8, 9—Average change in weight of dentures on wetting and drying at 37 deg. C. (99 deg. F.) is shown above

was developed: A stone (Hydrocal) model was poured directly into each finished denture. Gage marks were placed on each denture, just posterior to the last teeth. Each denture was weighed. The distance between the gage marks was measured with a micrometer microscope after the denture was placed on the gypsum model. The denture was placed in a desiccator and held at 32 percent relative humidity and 37 deg. C. (99 deg. F.) for conditioning for various lengths of time (Figs. 8 and 9). The denture was removed, reweighed and remeasured. The denture was immersed in distilled water and held at 37 deg. C. (99 deg. F.) for varying lengths of time (Figs. 8 and 9). The denture was removed, and its surface quickly dried. It was then weighed and measured. The denture was replaced in desiccator and reconditioned at 32 percent relative humidity and 37 deg. C. (99 deg. F.) for varying lengths of time (Figs. 8 and 9). The cycle was repeated. The periods of immersion in water and of conditioning in air were lengthened until the dentures in series B approached a constant weight.

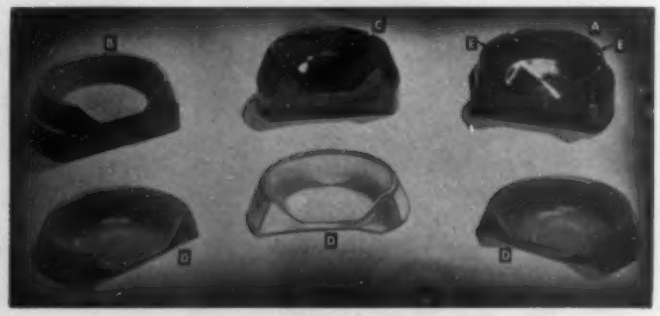
The procedure followed in weighing the denture after immersion was as follows: The denture in every case was allowed to come to room temperature before weighing. The wet denture was dried with a clean towel and the water remaining between the teeth was blown off with a chip syringe. This drying was carried out as rapidly as possible and the denture was immediately weighed to the nearest milligram on a magnetically damped analytic balance.

The results on the two series of dentures are shown in Figs. 8 and 9. Figure 8 shows that all of the dentures gained in weight on immersion and lost weight on drying, with the cellulose compound showing the maximum changes and the acrylic-vinyl resins the smallest changes. Figure 9 indicates that the dentures in general increased in dimension on immersion and decreased in dimension on drying. However, this effect is relatively small for the acrylic-vinyl resins and rubber, which in one instance showed a decrease in dimension on immersion. Individual values for the materials investigated are given in column 5 of Table III (see page 64).

Practical conclusions to be derived from the results obtained on these dentures are: 1) A denture in service should not be allowed to dry out; 2) the final adjustments for occlusion should not be made until the denture has become saturated. As the methyl methacrylate resin is more affected by wetting and drying than rubber or the acrylic-vinyl resins, these considerations apply particularly to it, although they are good practice in any case.

Curing shrinkage. The curing shrinkage of a denture base is of primary importance in determining the fit of the denture. The effective change in dimension of the material during curing is hard to evaluate precisely because of the many uncontrolled factors involved in making a denture. It is evident from a study of dentures cured and later cross sectioned in the investing material that the linear shrinkage is not the same in all directions because of the restrictions imposed by the mold. This is shown by the fact that the denture will conform fairly well to the bearing surface of the model, while there will be a space between the denture and the flasking plaster on the lingual and buccal surfaces.

The effect of this condition on the dimension across the posterior region was determined in a series of tests using a stainless steel die which simulates the upper arch form (Fig. 10). Two reference cross lines, E, were ruled on the crest of the ridge portion of the die about 1 cm. from the posterior border. The cases were waxed on the steel model and were carried through the conventional dental technic, except that



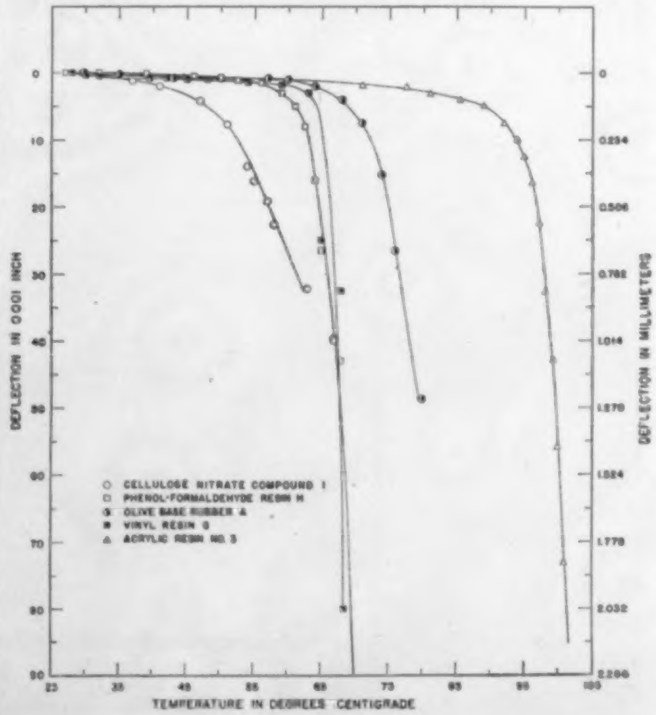
10—Stainless steel die and specimens of resins used in determining linear shrinkage during curing: A, stainless steel dies; B, gypsum replica of A; C, olive base-rubber form; D, acrylic resin forms. Forms C and D were molded on dies A, which at points E had fine cross-line reference marks. These marks were transferred to forms C and D during molding. Difference in distance between reference marks on die and resin forms represented shrinkage of resin during processing

the resin was cured on the die instead of on a gypsum replica of it. In all cases the details of processing were carried out as directed by the manufacturer of each material. After the flask came to room temperature, the denture form and die were removed. The fit of the form on the die could be used as a qualitative measure of shrinkage. The apparent linear shrinkage was computed from measurements of the distance between the two reference marks (Fig. 10, item E) on the model and corresponding marks on the resin which were transferred to it during processing. Measurements were made immediately after the resin form was removed from the flask. No temperature corrections were made for the differential thermal expansion of the metal die and the various resins or rubbers.

The results of these tests are reported in Table III, column 6. The values obtained for the methyl methacrylate resins are as low as 0.25 percent and as high as 0.45 percent. Methyl methacrylate resin has a linear thermal shrinkage (when unrestrained) of 0.65 percent over the temperature range 100 deg. C. (212 deg. F.) to 20 deg. C. (68 deg. F.) (curing temperature to room temperature). As the steel mold shrunk about 0.12 percent over the same range, the net shrinkage of the resin should be about 0.53 percent—in other words, the resin should be 0.53 percent smaller than the die from thermal expansion alone. The fact that the measured shrinkage is lower than the computed thermal contraction indicates the resin adapts itself to the die during cooling. The minimum temperature at which this adaptation takes place for one of the methyl methacrylate resins was calculated to be approximately 90 deg. C. (194 deg. F.).

Column 7 of Table III contains the values for the apparent net dimensional changes obtained by taking the differences between the values for the uncorrected curing shrinkages (obtained on the steel die) and the dimensional changes of the wet dentures. These values are estimated to be between 0.05 and 0.15 per cent high, as they have not been corrected for the thermal contraction of the steel die. This correction was not applied because the temperatures at which the resins cease to

11—***Effect of temperature on bending of denture materials***



flow were not known for the conditions of test. These values are useful only for comparing materials. The net change is less for acrylic-vinyl and acrylic-styrene resins than for methyl methacrylate resin or rubber.

Softening temperature. The relative effect of temperature on five classes of denture material is shown in Fig. 11. These curves were obtained by placing a 50-gm. load on a standard transverse test specimen (B in Fig. 2) in water, and by observing the deflection of the specimen as the temperature of the water was raised 1.5 deg. C. (2.7 deg. F.) a minute. The cellulose nitrate compound had the lowest softening range and methyl methacrylate resin the highest; while the phenol-formaldehyde resin, vinyl resins and rubber were intermediate. The low softening temperature of the cellulose nitrate compound at this low load indicates that it may easily be distorted when hot foods are chewed or when the denture is washed in hot water. The high softening range of methyl methacrylate resin is therefore a distinct advantage.

Molding dentures. In working with methyl methacrylate resins and certain of its copolymers, several conditions arise which cause gas bubbles to form inside the specimen during curing. If the specimen is cured at a high temperature, some of the monomer (liquid) is vaporized and trapped before it is completely polymerized. This causes porosity. A thick specimen of resin can easily and inadvertently be cured too rapidly because, in addition to the external heat applied, there is also considerable heat evolved during polymerization. The amount of heat developed will, of course, depend upon the size and shape of the specimen. As the resin is a poor thermal conductor, the heat formed during polymerization cannot readily escape. Consequently, the interior of the specimen becomes much hotter than the temperature of the water bath or vulcanizer. Some of the monomer will be vaporized and trapped in the resin, the plasticity of which is rapidly decreasing. Bubbles so produced are usually relatively large and located in the central part of the specimens. They can be prevented by curing the resin at from 70 to 80 deg. C. (158 to 176 deg. F.) for 1 hour and then gradually raising it to 100 deg. C. (212 deg. F.).

If the powder and liquid (polymer and monomer) are not mixed long enough prior to packing in the mold, bubbles will also be formed. A clear cake was obtained when the mixing was carried on for 5 minutes before the resin was packed into the mold, while a cloudy cake resulted when the mixing was carried on for only 1 minute.

Sometimes insufficient pressure on the flask or insufficient material in the mold will permit bubble formations in the resin, apparently from the monomer vapor. These gas bubbles in the cured resin are under reduced pressure, as a partial vacuum was found to exist in them. This was verified when a drop of dye solution was placed above a bubble and a small hole was drilled under the dye through the resin to the bubble. The dye rushed into the bubble space because of a reduced pressure within the bubble. Bubbles in a block of cured methyl methacrylate can be eliminated by the application of sufficient heat and pressure. If the foregoing precautions are taken, one should not be troubled by porosity in methyl methacrylate resin. The copolymers of methyl methacrylate, vinyl chloride and amyl acetate were more difficult to mold than methyl methacrylate.

Identification of resins by flame test. Frequently it is desirable to determine what resin has been used in making a denture. This is especially true when a patient presents a denture constructed of unknown materials for repair or where one desires to check the type of resin in a denture ordered on pre-

scription from a dental laboratory. A simple flame test will give a fairly reliable index of the type of resin used. This test consists in carefully and slowly flaming a small shaving from the denture on a thin sheet of metal and of observing its burning characteristics, ash and odor.

Cellulose nitrate compounds such as Hecolite, Parfait R and so forth ignite quickly and burn violently with a yellow, sooty flame. The residue is a network of carbon which maintains the shape of the burned piece. It has a unique appearance which is the most important identifying clue.

Phenol-formaldehyde resins such as Luxene 37, Duratone and Aldenol do not burn easily or rapidly unless the thin metal sheet becomes visibly red. It burns slowly with a yellow flame when placed in the Bunsen flame, but may not continue to burn when the test piece is withdrawn from the flame. The resin does not melt and the test piece preserves its form after flaming, leaving a skeleton of carbon. The most characteristic and definite guide in the identification is the strong phenol (carbolic acid) and formaldehyde odors present.

Vinyl resins such as Resovin or Vydon burn with a dense, sooty flame when held in the Bunsen flame, but do not continue to burn when withdrawn. The resin melts as it burns in the flame and gives off an acetic acid (vinegar-like) odor. A hollow carbon shell remains after burning.

Methyl methacrylate resins such as Vernonite, Crystolex, Lucitone, Densene and Acralite burn slowly with a yellow-tipped blue flame and are entirely consumed if the resin is clear. If the resin is colored, a thin white residue consisting probably of inorganic pigments and opacifiers is left after flaming. As the resin burns it appears to depolymerize and probably forms the monomer, which boils off and burns rapidly. A characteristic odor is present.

Before attempting to identify the thin shaving from a finished denture, the operator should conduct extended experiments on a variety of known resins.

Advantages and disadvantages of methyl methacrylate resin. It has now been about four years since methyl methacrylate resin began to be extensively used as a denture base. The data accumulated during this time both from clinical and from laboratory tests seem sufficient in quality and quantity to evaluate its relative worth when compared with other available materials. In making such a comparison, consideration will be given to general characteristics, such as lifelike appearance, which will, of course, be judged qualitatively; and physical properties having a dental significance, which can be treated quantitatively.

The general characteristics of methyl methacrylate resin are so good in comparison with those of other materials that its continuously increasing use as a denture base is gradually crowding out other materials. The oral tissues normally remain in a healthy condition when in contact with methyl methacrylate resin. It is true that there have been a few cases of allergy reported, but apparently no more than occur with rubber or with vinyl resins.

Its lifelike appearance is rivaled only by the acrylic-vinyl copolymers and its color stability when exposed to light is not equaled by any other denture resin now in use. Its pleasing appearance is therefore maintained indefinitely if color-fast pigments and opacifiers are used in compounding the denture material. It also remains clean in the mouth and does not develop an offensive odor or taste even though it does absorb a comparatively large amount of water. The technic of working the material is simple and requires the minimum of equipment. It is easily repaired and the repair, if well done, is not detectable upon visual inspection.

One of the principal troubles encountered in using both

methyl methacrylate resin and its copolymer with vinyl acetate and vinyl chloride is the splitting of porcelain teeth during the processing of the case. Another fault often found in thick sections of dentures made of methyl methacrylate resin is porosity. A discussion of how the occurrence of these two defects may be reduced or even eliminated was given in the section on molding dentures.

A quantitative comparison of the organic denture base materials on a physical and chemical basis was made in the sections dealing with those properties and in Tables III and IV. It is well to relate briefly some of these comparisons. Methyl methacrylate resin absorbs from two to three times as much water as the acrylic-vinyl copolymers. In doing this it may expand as much as 1 percent (linear basis), which is from two to three times the expansion of the acrylic-vinyl copolymers. The expansion of methyl methacrylate resin in water more than compensates for the curing shrinkage so that the net linear change is on the plus side and results in a denture from 0.3 to 0.6 percent oversize. The acrylic-vinyl dentures would, when rated by the same plan, be only slightly over or under size (about 0.1 percent), while rubber, regardless of the type used, was always undersized (0.3 to 0.7 percent). The deflection of methyl methacrylate resin under transverse loading is about the same as that for the base rubbers and the acrylic-vinyl copolymers. Methyl methacrylate resin is, with the exception of phenol-formaldehyde denture resins, about the hardest plastic used as a denture base.

The conclusions reached in these comparisons may be summed up by stating that methyl methacrylate resin and the vinyl-acrylic copolymers are the most suitable organic denture base materials now available.

Methyl methacrylate resin, as before stated, is available in three forms—the powder-liquid, the plastic cake and the powder. The powder-liquid form is the most used and the powder the least used form. The relative popularity is caused by a number of factors among which are: 1) The powder-liquid form is the easiest to process; 2) the powder is the most difficult to process and requires special and more elaborate equipment than does either the powder-liquid and the plastic cake; 3) the plastic cake has a short shelf-life at room temperature, while the powder-liquid and powder may be stored at room temperature indefinitely without hardening; 4) the powder-liquid is more widely distributed and is probably the most economical in many instances. It should be noted that when processed the plastic cake form sometimes yields a slightly stiffer material than do the powder-liquid or powder forms.

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Plastics in wartime

(*Continued from page 45*) quently requests that contractors work extra shifts or overtime. When the contractor is willing to accelerate deliveries under existing contracts additional compensation may be paid to the contractor for the extra costs which result from his overtime or extra shifts.

Another question which prospective contractors probably ask themselves is, "What financial assistance can I obtain while in the performance of Government contracts?" There are several ways by which your Government may help you, directly or indirectly. One indirect assistance comes from Section 124 of the Internal Revenue Code which permits a corporate manufacturer in computing his taxable income or profits to amortize the cost of his emergency facilities over a five-year period instead of on the usual depreciation schedule. To obtain this benefit and cut your taxes you must secure from the War Department a "certificate of necessity" to file with your tax returns. This is done by filing an application with the Tax Amortization Unit, Office of the Under Secretary of War, within six months after your acquisition of your new emergency equipment. If you can show that your plant or equipment is "necessary" to the national defense program, you will be granted a certificate. To prove your equipment is necessary, you must show that there is an existing or prospective shortage of facilities in the industry for the production of the supply being produced by your facility. It is not enough that you need the particular equipment; you must show that an over-all shortage exists, or is in prospect, in the industry at large.

Another indirect method of according financial assistance to Government contractors is the recent statute which permits the assignment of claims under Government contracts to a bank, trust company or other financing institutions. Details about borrowing under such assignments can be obtained from your nearest Federal Reserve Bank.

A more direct method of lending financial assistance to contractors, and one which probably will become very popular in the very near future, is the making of advance payments under Government contracts. In order to speed the war effort, it is now the established policy of the War Department to make advance payments, before deliveries, upon the request of the contractor, where production will be speeded up. The authority has been delegated to the contracting officers in the field to make advance payments, in their discretion, up to $100,000 or no more than 30 per cent of the contract price, without interest. Advance payments must be secured, but the giving of a performance bond is not necessarily required. It is not contemplated that such advance payments will be made when satisfactory financial assistance is easily obtained from the usual credit sources, unless the prosecution of the war is facilitated thereby, as, for example, if supplies can thus be procured more economically or production can be speeded up. However, I am sure that a great many companies who otherwise could not handle a Government contract will be able to do so under such provisions for advance payments.

To sum up, gentlemen, your Government is definitely interested in manufacturers, large or small, and is trying to help them share the work. So find out which branch can use your product or, better still, see if you can produce what the various offices need; get your name on the bidders' lists; make your price reasonable; offer to subcontract as much as possible and to speed deliveries—and not only will you get a share of this Government business, but Uncle Sam will help you, even financially if necessary, to perform.

Two days ago, our President told Donald Nelson: "Victory

depends in a large measure on the increased war production we are able to get from our factories and arsenals. . . . This is total war. We are all under fire, soldiers and civilians alike. No one is a spectator. We are all belligerents. To win we must fight."

That message was intended for American manufacturers like you men here. You must display the same boldness, imagination and success in the battle for production as our soldiers and sailors display in the battle with Japan. We have shown the world that we have men like MacArthur in our forces of destruction. You must show the world we have men like MacArthur in our forces of production.

Injection-molded Mycalex

(***Continued from page 54***) in length up to twice the hole diameter. Through holes can be molded up to five times the diameter. Minimum hole diameter is about $^1/_{16}$ in., and holes should not be located too near the edge of the part.

B. Radii should be used on all corners and edges except on the edge coming at the parting line of the mold. Radii aid mechanical strength of the mold as well as that of the molded part, and help insure against undercuts in the mold.

C. One-fourth degree taper is minimum for all vertical walls, including holes. Wherever possible, more should be used. The slightest undercut will trap the molded part and damage it when it is extracted.

D. Minimum moldable cross section thickness of parts is about $^1/_{32}$ in. and depends on adjacent cross sections.

E. Tolerances on all dimensions except "build-up" can be held to plus or minus .002 in. for dimensions less than 1 inch, and plus or minus .0025 in. per inch on dimensions over 1 inch. "Build-up," or increase in thickness at the parting line, adds another .003 to .005 in. to the plus side of the vertical tolerance.

F. Threaded metal inserts are cheaper and stronger than molded threads. Tapping holes in the injection-molded material is unsatisfactory.

G. Inserts should be of some metal which does not deform under molding pressure. (Aluminum deforms.)

H. Inserts must be properly anchored to prevent turning or sliding. Otherwise the difference in coefficient of thermal expansion would cause most metal inserts to loosen up after the part cools.

I. Finishing operations on the injection molded material are limited to drilling holes, surface sanding and grinding operations. The compression-molded material machines better than the injection-molded material.

J. Size of part is limited by existing equipment. When production warrants, larger facilities will be made available.

K. Continuous service can be expected at temperatures up to 325 deg. C.

L. Minimum test-bar flexural strength is approximately 8000 lb. per sq. in.

M. Impact strength is equivalent to or better than radio grade porcelain. Charpy tests on unnotched $^1/_2$ by $^1/_8$ by 5-in. bars show .10 to .12 ft.-lb.

N. Dielectric strength measures 300 volts per mil or higher at 100 deg. C by step test on $^3/_{32}$-in. thick disks.

No design story is complete without some mention of costs. Because of extreme pressures and temperature, molds for injection-molded parts of this insulating material are more expensive than for the same parts in organic plastics or fired ceramic compounds. Cost of the compound is a relatively

small item for most parts. The compound is not for sale in the unmolded form. Parts price varies so widely that no fair comparison with that of other materials can be made. The best method toward reducing parts price is to use multiple cavity molds. From one-cavity to eight-cavity molds have been or are being built and the limit has not yet been reached.

To conclude, an improved manufacturing technique has been applied to an accepted and proved product. Specifically, the injection-molded insulating material offers moderately intricate parts held to good dimensional tolerances. In a larger sense, however, it means that our soldiers and sailors will get better communication equipment more quickly and that American planes may fly higher than those of Germany or Japan.

Marine bearings

(*Continued from page 34*) the bearing is made in two sections, separated by longitudinal keeper strips on each side, which also serve as water channels for lubrication. After the bushings have been bored smooth, these two curved liner segments are easily slipped into the bronze bushing of the stern tube, and tapped home by moderate blows with a maul in the minimum possible installation time. Not only does the full arc liner provide maximum bearing surface, but it is also designed for maximum proper lubrication.

On replacement jobs in which circumstances will not permit conditioning the stern tube bushing for the full arc type of bearing, one of the other types of design may be used. For the solid or split stern tube bushing of the plane type, the "segmented arc" type of bearing may be installed. These narrow arc sections are pack-fitted in the bushing and then bored for proper alignment and running clearance.

For the ribbed type stern tube bushing, "strips" are supplied for fitting between the ribs, the bearing then being bored for alignment and running clearance.

Laminated plastic bearings have been constructed up to 24 in. inside diameter with 1 $^1/_4$-in. wall, and 60-odd inches in length, this particular bearing being made up of six shells.

The advantages of laminated plastic stern tube bearings, as outlined here, are far from theoretical. They have been demonstrated under all sorts of conditions, in all types of ships, on both fresh and salt water. Among our users today we list many of the largest and most exacting owners, who have subjected laminated plastic stern tube and pintle bearings to the most severe service over a period of years. A few figures from actual records of stern tube bearing service may be of interest here:

Boat	*Wear rate*
Tug	$^5/_{64}$ in. for 33 months
Tanker	.042 in. for 24 months
Tanker	$^1/_{16}$ in. for 8 months
Tanker	.003 in. for 15 months
Tug	$^1/_4$ in. for 25 months
Tug	$^1/_8$ in. for 41 months
Tug	$^3/_{32}$ in. for 24 months

These rates of wear are variable because of different operating conditions, but in each of the above cases the rates of wear of lignum vitae have been far exceeded.

With America's shipways on both coasts and her inland waters humming day and night, with the cry always for more and more bottoms, the demand for better materials, quickly produced and quickly installed, is steadily increasing. The stern tube bearing application is but one of the many in which plastics fill this need.

Naftolen in plastic coatings

(Continued from page 74)

The following formulas are typical examples of Naftolen-containing varnishes:

Baked enamel for cans, etc.

Bakelite BR-254	160 lb.
China wood oil	128 "
Perilla oil	32 "
Naftolen 550	80 "

This varnish was heated for 20 min. at 230 deg. C. to a viscosity between E and F of the Gardner Scale and reduced to 50–55 percent solid content with Shell Solvent TS-28. After adding a trace of cobalt lead drier, the varnish was baked from 10 to 15 min. at 190 deg. to 210 deg. C.

Spar varnish	1	2
Arochem 130	100 lb.	100 lb.
China wood oil	100 "	200 "
Naftolen 550	80 "	200 "

These varnishes were prepared as follows: China wood oil and resin were heated in 20 min. to 230 deg. C. and held at this temperature until a viscosity of between E and F (Gardner Scale) was reached (25 min.). Then the Naftolen was added and the varnish was heated for five more minutes at 190 deg. C. The varnish was reduced to 55 per cent solid content with Shell Solvent TS-1. A combination of cobalt and lead soligen was used as drier.

Chlorinated rubber lacquers

The hydrocarbons are very efficient plasticizers for all chlorinated rubber solutions used for coating or impregnation purposes. The best results are obtained in chlorinated rubber-Naftolen mixtures of a proportion 1:1 or 1:1.5, meaning that the chlorinated rubber is extended by 100 percent or more. Moreover, the new very scarce plasticizers for chlorinated rubber mixtures, such as dibutyl phthalate, can be entirely replaced by these hydrocarbons, except where the color would be disturbing.

The unsaponifiable character of the hydrocarbons has a favorable effect on the chemical resistance of chlorinated rubber. The rust spot test applied in testing the alkali resistance of chlorinated rubber shows that the alkali resistance is increased from a few hours in ordinary chlorinated rubber to six days in a Naftolen-chlorinated rubber solution of the proportion 1:1.

Summary

The use of Naftolen is recommended for the following purposes:

1. For synthetic resins of the phenol-formaldehyde type condensed with an alkaline catalyst. The production of resins containing the hydrocarbons can be accomplished with standard equipment. An increase in the catalyst content does not disturb the distillation because these resins are thinly liquid until the end of the distillation.
2. As a substitute for China wood oil in punching stock. A certain percentage of China wood oil has to be retained or replaced with another vegetable oil.
3. In oleoresinous varnishes. The hydrocarbon material is used with both drying oil and resin. It is recommended to prevent skinning and to improve alkali resistance and electrical properties of both resins and varnishes.
4. As a plasticizer for chlorinated rubber.

BUY DEFENSE BONDS AND STAMPS!

CLASSIFIED

➡ WANTED: THERMOPLASTIC SCRAP or rejects in any form, including Acetate, Butyrate, Styrene, Acrylic and Vinyl Resin materials. Submit samples and details of quantities, grades and colors for our quotation—Reply Box 508, Modern Plastics.

➡ WANTED: PLASTIC SCRAP OR REJECTS in any form, Cellulose Acetate, Butyrate, Polystyrene, Acrylic, Vinyl Resin, etc. Also wanted surplus lots of phenolic and urea molding materials. Custom grinding and magnetizing. Reply Box 318, Modern Plastics.

➡ FOR SALE: Stokes Rotary Tablet Machine, Type DD, 500 to 700 Tablets per minute, ⅜" to 1 1/16" Tablets. 15 x 15" Watson-Stillman Transforming Press with Pushback and Ejectors. Reply Box 512, Modern Plastics.

➡ HIGHEST PRICES PAID FOR PLASTIC SCRAP OR REJECTS, any form, Cellulose Acetate, Butyrate, Polystyrene, Acrylic and Vinyl Resins. Also Phenolic and Urea molding materials. We do Custom Grinding and Magnetizing. Reply Box 476, Modern Plastics.

➡ WANTED: Stainless Steel or Nickel Kettle, Vacuum Pan, Hydraulic Press, Preform Machine and Mixer. Reply Box 275, Modern Plastics. No dealers.

➡ FOR SALE: 16—SEMI-AUTOMATIC HYDRAULIC MOLDING PRESSES from 15" x 18" to 32" x 36" platen surface, rams 9" dia. to 20" dia. ram, all with hydraulic pullbacks and slotted heads for die attachments. 1—W. S. Hydro-Pneumatic Accumulator 2500 PSI, 8 gal. with IR m.d. air compressor; 1—W.S. 15" x 18" Hyd. press, 9" dia. ram. 4" posts; 1—Bethlehem 38" x 78" Hyd. Press, 20" dia. ram; 1—Birmingham 24" x 36", 12" ram Presses, 3 openings. 2—H.P.M. 20" x 20" Hydraulic Presses, 10" rams; 1—W.S. Hand Pump; 1—32" x 32" Hydraulic Press, 24" ram, 6 openings. Royale # ½ Perfection Tuber. 7—W. & P. Mixers; Tablet Machines. Send for complete list. Reply Box 446, Modern Plastics.

➡ WANTED—Research Chemist with actual working knowledge of formulation and production of synthetic resins, particularly of the phenolic type, to develop new thermo-setting resins from certain natural raw materials. Reply Box 518, Modern Plastics.

➡ FOR SALE: Acrylic scrap—injection and compression. Also virgin acrylic powder and acrylic liquid (monomer). Write for samples and quotations. Reply Box 528, Modern Plastics.

➡ WANTED: Reed-Prentice 2 or 4 oz. injection molding machine. Reply Box 475, Modern Plastics.

➡ FOR SALE: 400 ton horiz. Hydraulic extrusion press. Hydraulic scrap baler, 80 ton, 6½" ram, 90" stroke, 5000 lbs. per sq. in. W. & P. mixer, size 15. 75 ft. link belt conveyor, 36" wide. Large stocks of Hydraulic presses, pumps & accumulators, preform machines, rotary cutters, mixers, grinders, pulverizers, tumbling barrels, gas boilers, etc. Send for Bulletins # 156 and # 138, and L-17. We also buy your surplus machinery for cash. Reply Box 439, Modern Plastics.

➡ WANTED: 2 foremen for night shifts to take complete charge of medium sized injection molding department in Western New York. Write fully as to education, experience, availability and compensation desired. Excellent opportunity in expanding plant. Reply Box 538, Modern Plastics.

➡ EXECUTIVE WITH BROAD EXPERIENCE: Sales, development, export, financing, office management, purchasing, negotiate contracts. Desires to enter chemical or plastics field. Business degree, native citizen, 43, married, protestant. Speak French, Dutch. References. Connection with progressive company manufacturing or distributing war products essential but one with good peacetime prospects. Location near New York City preferred. Reply Box 539, Modern Plastics.

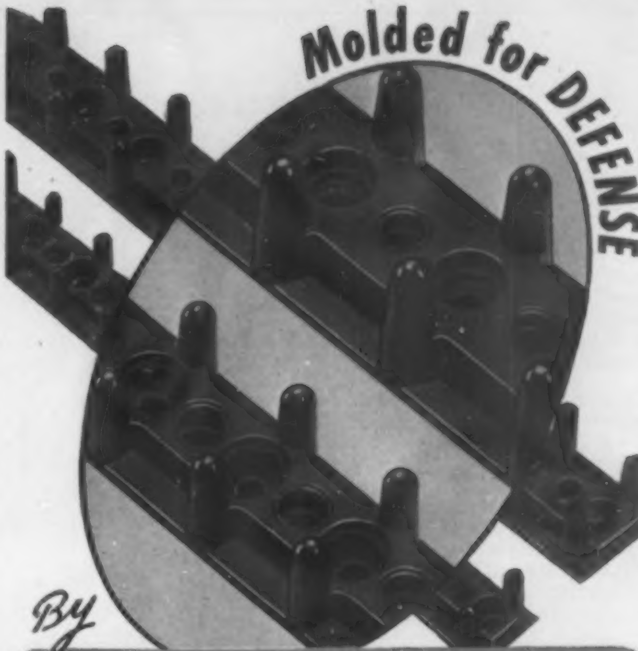
➡ HELP WANTED: Concern located in metropolitan New Jersey interested in services of engineer experienced in extruding machine and rubber mill operation who has some background in drafting and development work. Personnel of this concern notified of advertisement. Reply Box 540, Modern Plastics.

➡ WANTED IMMEDIATELY: Second hand mold for manufacture barber's comb for use Reed-Prentice injection molding machine D6. Cash payment New York. Communicate air mail, Rozier Hijo, Aereo 67, Barranquilla, Colombia.

➡ WANTED: Manufacturer desires complete unit, consisting of Hydraulic Press with Steam Platens, Pump, Boiler, etc., for molding acetate sheets 20" x 20" or larger. Also desires 150 or 200 Ton Hydraulic Press in perfect operating condition with Steam or Electric Platens, Surface 24" x 24" or larger—15" Ram—Hydraulic Pullbacks, Arrangement for Die Attachment. Reply Box 541, Modern Plastics.

➡ PROGRESSIVE BAKELITE FABRICATING PLANT located Greater New York seeks capable man to run plant. Must be thoroughly experienced in Machine Shop Practice and able to handle men. State full particulars, age, experience and salary desired. Real opportunity and future for live wire. Reply Box 542, Modern Plastics.

➡ FOR SALE: Modern molded rubber factory, good midwest city, large site for expansion, cost nearly $100,000, suitable for conversion to plastics, will take substantial discount for cash or easy terms to responsible buyer. Reply Box 543, Modern Plastics.




Swivel 78-8BS


Swivel 7AS-8BS

Index to Advertisements

American Cyanamid Co., Plastics Div. 32
American Hard Rubber Co. 111
American Insulator Corp. 103
American Screw Co. 11
Atlas Valve Co. 118
Auburn Button Works 28

Baldwin Locomotive Works 26
Baldwin-Southwark Corp. 26
Ball & Jewell 122
A. Bamberger 121
Barco Mfg. Co. 123
Becker, Moore & Co., Inc. 117
Birdsboro Steel Foundry & Machine Co. 20
Boonton Molding Co. 12
Boston Technical Institute 115
Bristol Co. 11
Brosites Machine Co., Inc. 103

Cambridge Instrument Co., Inc. 108
Carbide & Carbon Chemicals Corp., Plastics Div. .... Inside Back Cover
Carpenter Steel Co. 110
Carter Products Corp. 113
Fred S. Carver 115
Catalin Corp. 3
John J. Cavagnaro 117
Celanese Celluloid Corp. 9
Celluplastic Corp. 99
Central Screw Co. 11
Chandler Products Corp. 11
Chicago Molded Products Corp. 16
Claremont Waste Mfg. Co. 119
Classified 123
Arthur Colton Co. 115
Continental-Diamond Fibre Co. 18
Continental Screw Co. 11
Corbin Screw Corp. 11
Cruver Mfg. Co. 79

Diemolding Corp. 121
Dow Chemical Co. 91
E. I. du Pont de Nemours & Co., Plastics Dept. 7
Durez Plastics & Chemicals, Inc. .... Inside Front Cover

Eagle Tool & Machine Co. 114
Erie Resistor Corp. 10

Foredom Electric Co. 107
Formica Insulation Co. 30
Fortney Mfg. Co. 113
French Oil Mill Machinery Co. 113

General Electric Co. .... Back Cover
General Industries Co. 95
Gering Products, Inc. 113

John Hassall, Inc. 114
Hercules Powder Co., Inc. 25
Heyden Chemical Corp. 99
Hydraulic Press Mfg. Co. 77

International Screw Co. 11

Kearney & Trecker Corp. 83
Kingsley Gold Stamping Machine Co. 121
Kuhn & Jacob Molding & Tool Co. 116
Kurz-Kasch, Inc. 101
Kux Machine Co. 111

Lamson & Sessions Co. 11

Marblette Corp. 17
Markem Machine Co. 97
McAleer Mfg. Co. 119
Mears-Kane-Ofeldt, Inc. 112
Metasap Chemical Co. 115
Mica Insulator Co. 15
Michigan Molded Plastics, Inc. 119
Midwest Molding & Mfg. Co. 111
Elmer E. Mills Corp. 19
Monsanto Chemical Co. 21
H. Muehlstein & Co., Inc. 101

National Plastic Products Co. 122
National Screw & Mfg. Co. 11
National Vulcanized Fibre Co. 29
Newark Die Co., Inc. 120
New England Screw Co. 11
Nixon Nitration Works, Inc. 27
Northern Industrial Chemical Co. 123

Tinius Olsen Testing Machine Co. 85
Owens-Illinois Plastics Div. 24

Charles Parker Co. 11
Parker-Kalon Corp. 6, 11
Pawtucket Screw Co. 11
Pheoll Manufacturing Co. 11
Plaskon Co., Inc. 56–57
Plastic Molding Corp. 120
Plastics Industries Technical Institute 22
Plastimold, Inc. 112
Precision Fabricators, Inc. 109

Racine Tool & Machine Co. 116
Reed-Prentice Corp. 4
Reynolds Spring Co. 31
Rohm & Haas Co. 13
John Royle & Sons 119
Russell, Burdsall & Ward Bolt & Nut Co. 11

School of Plastics 115
Scovill Manufacturing Co. 11
Shakeproof, Inc. 11, 93
Sinko Tool & Mfg. Co. 23
Standard Tool Co. 121
Southington Hardware Mfg. Co. 11
F. J. Stokes Machine Co. 87
Stricker-Brunhuber Corp. 118

Taylor Instrument Co. 14
Tech-Art Plastics Co. 81
Tennessee-Eastman Corp. 75
Wm. R. Thropp & Sons Co. 117
Timken Roller Bearing Co. 89

Union Carbide & Carbon Corp. .... Inside Back Cover
Universal Plastics Corp. 105

Victor Metal Products Corp. 107

Waterbury Button Co. 97
Watson-Stillman Co. 8
S. S. White Dental Mfg. Co. 117
Whitney Screw Corp. 11
R. D. Wood Co. 105
Worcester Moulded Plastics Co. 109

Modern Plastics

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